SILICON CHIP

MARCH 2013
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03
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Are Wind Turbines Making You SICK? Build this low-cost

INFRASOUND DETECTOR

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2013/2014 CATALOG
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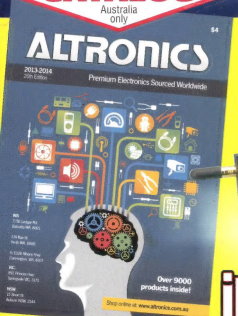

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LeoStick (Arduino Compatible)

A tiny Arduino-compatible board that's so small you can plug it straight into your USB port without requiring a cable! Features a full range of analogue and digital I/O, a user-controllable RGB LED on the board and an on-board Piezo/sound generator.

- ATmega32u4 MCU with 2.5K RAM and 32K Flash
- 6 analogue inputs (10-bit ADC) with digital I/O, 14 extra digital I/O pins

XC-4266

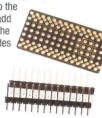
$29.95

LeoStick Prototyping Shield

Add your own custom parts to the LeoStick to build projects or add more I/O connectors. Fits on the top of the LeoStick and provides you a free matrix of plated-through holes for your own use.

- 64 general-purpose plated holes for your parts
- Includes male header pins
- Gold-plated surface

XC-4268



$7.95

"Eleven" Arduino-Compatible Development Board

An incredibly versatile programmable board for creating projects. Easily programmed using the free Arduino IDE development environment, and can be connected into your project using a variety of analogue and digital inputs and outputs. Accepts expansion shields and can be interfaced with our wide range of sensor, actuator, light, and sound modules.

- 8 analogue inputs

XC-4210

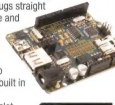
$39.95

USBDroid, Arduino-compatible with USB-host Support

This special Arduino-compatible board supports the Android™ Open Accessory Development Kit, which is Google's official platform for designing Android™ accessories. Plugs straight into your Android™ device and communicates with it via USB. Includes a built-in phone charger.

- USB host controller chip
- Phone charging circuit built in
- 8 analogue inputs
- microSD memory card slot

XC-4222



$69.95

AS DESCRIBED IN THIS ISSUE

EtherTen (100% Arduino Compatible with Onboard Ethernet)

Includes onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, and even Power-over-Ethernet support.

- ATmega328P MCU running at 16MHz
- 10/100base-T Ethernet built in
- Used as a web server, remote monitoring and control, home automation projects
- 14 digital I/O lines (6 with PWM support)
- 8 analogue inputs

XC-4216

$69.95

Relay Drivers

- Drive relay coils of 5VDC to 24VDC (with external power supply)
- Suggested relays like SY-4052 are rated at 2 x 5A @ 240VAC
- Plugs straight into your Arduino-compatible board
- Individual LED status display on every output channel
- LED status display for external power

4 Channel Relay Driver Module for Arduino

Easily drive up to 4 relays using logic-level outputs from your Arduino or other microcontroller. Isolates your microcontroller from the relay coils using FETs, includes back-EMF protection, and works with a wide range of relays.

- Size: 36(W) x 23(H) x 12(D)mm

XC-4278

$13.95

EtherMega, Mega sized Arduino Compatible with Ethernet

The ultimate network-connected Arduino-compatible board: combining an ATmega2560 MCU, onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, Power-over-Ethernet support, and even an onboard switchmode voltage regulator so it can run on up to 28VDC without overheating.

- 10/100base-T Ethernet built in
- 54 digital I/O lines
- 16 analogue inputs
- MicroSD memory card slot
- Prototyping area
- Switchmode power supply

XC-4256

$119.00

PCB Mount Solid State Relay 5V

Low profile PCB mounting solid state relays with LED input status indication. Suitable for applications such as I/O interfaces and programmable logic controllers.

- Control voltage range:4 - 6VDC

SY-4092 ***was $7.95***

$4.95

SAVE $3

8 Channel Relay Driver Shield

Drive up to 8 relays from an Arduino using just 2 I/O pins. It communicates with your board using I2C, so you can even stack several shields together to drive 16, 24, or more outputs!

- Size: 52(W) x 66(H) x 12(D)mm

XC-4276

$34.95

ProtoShield Basic

A prototyping shield for the Eleven (XC-4210) and USBDroid (XC-4222). Provides plenty of space to add parts to suit any project, keeping everything neat and self-contained. Includes dedicated space to fit a power LED and supply decoupling capacitor.

- Gold-plated surface

XC-4214

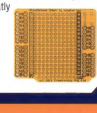
$4.95

ProtoShield Short

A dedicated short version prototyping shield for EtherTen (XC-4216) and EtherMega (XC-4256). This special prototyping shield is designed to fit neatly behind the RJ45 Ethernet jack, allowing you to stack your Ethernet-based projects right on top with standard headers.

- Pads available to fit a reset button
- Gold-plated surface

XC-4248



$4.95

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3 DAY SALE

GSP-795 Pneumatic Round Stool

- ø360mm seat
- 675-795mm seat height - pneumatic
- Chrome plated steel frame with footrest
- Non slip rubber feet

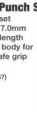
$88 (A359)

NEW RELEASE

Centre Punch Set

- 3 piece set
- 2.5, 5.5, 7.0mm
- 150mm length
- Knurled body for a firm safe grip

$15 (P367)



9" Drill Press Locking Clamp

- Fastens to drill press slot
- Secures work pieces tightly
- Maximum jaw opening 2"
- Throat depth 3"

$16.50 (C103)

Extra Long Ball End Hex Key Sets

Imperial Set (H800)
- 1/16" - 3/8"

Metric Set (H801)
- 1.5 - 10mm

$11 EACH

Parallel Sets

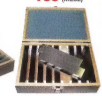
Precision ground to 0.0003" tolerance
- M250 152.4mm long
- M252 150mm long

4 Matched Pairs

$82.50 (M250)

9 Matched Pairs

$165 (M252)



Metric & Imperial Drill Gauge

- Metric / Imperial
- Stainless steel
- 1-13mm
- 1/16 - 1/2"

$13.90 (M568)

RT-3 Rotary Table

- 36-1 ratio
- 75mm table
- Vertical & horizontal
- Hand wheel graduated in 10min divisions
- 4 T-slots

$88 (R001)

TRT-4 Tilting Rotary Table

- Tilting 0-90°
- 36-1 Ratio
- 100mm table
- Graduations 0-10° in 5' divisions
- 66mm height from flat position

$159.50 (R0014)

Rotary Tables

- High level of accuracy
- Hardened & ground worm gear
- Gear ratio 90-1 + Vernier reading 10 seconds
- Table is graduated to 360° so one turn of the handle moves the table 4°
- Adjustable back lash
- Smooth operation for precision work
- Can be used horizontally or vertically

HV-4 Rotary Table
- 110mm diameter
- 80mm height
- 3 T-slots, 11mm

$242 (R005)

HV-6 Rotary Table
- 152mm diameter
- 80mm height
- 3 T-slots, 11mm

$264 (R006)

BS-0 Dividing Head - Semi Universal

- 100mm
- Suitable for direct & indirect indexing
- Hardened & ground spindle
- Designed to carry out all types of gear cutting, precision dividing

$434.50 (D001)

Slot Drill & End Mill Set

- Manufactured from HSS, with a tinite coated finish

Type	No. of Pieces	Sizes	
Metric	10	6, 10, 12, 16, 20mm	$65.45 (M330)
Imperial	10	1/4", 3/8", 1/2", 5/8", 3/4"	$65.45 (M332)
Metric	12	4, 5, 6, 8, 12mm	$65.45 (M333)
Imperial	12	3/16", 1/4", 5/16", 3/8", 7/16", 1/2"	$65.45 (M335)

Parting Tool Kits

Consisting of:
- Parting off block, blade, 2 x inserts, ejector & allen key
- 12, 16 & 20mm kits include 2 Inserts

Blade size	Centre Height	Insert Width	
26 x 2mm	12mm	2mm	$157.30 (L464)
26 x 2mm	16mm	2mm	$157.30 (L465)
26 x 3mm	20mm	3mm	$157.30 (L466)

3 Piece Turning Tool Kits

- 1 x right hand tool
- 1 x left hand tool
- 1 x right hand boring bar
- 10 x carbide inserts to suit

Size	Insert Type	
12mm	(TCMT110204)	$214.50 (L450)
16mm	(TCMT110204)	$233.20 (L451)
20mm	(WNMG080408)	$303.60 (L452)

Threading Tool Kit

- Includes external threading tool (L470)
- Includes external & internal threading tool (L471, L472)

Size	No. of Inserts	
12mm	10	$102.30 (L470)
16mm	4	$112.20 (L471)
20mm	4	$158.40 (L472)

High Speed Steel Bits

- High speed steel 5% cobalt

Tool Bit Size	Qty in Pack	
SQ x 2 1/2" Long	3	$8.25 (L0001)
3/16" SQ x 2 1/2" Long	3	$10.00 (L0002)
1/4" SQ x 2 1/2" Long	3	$11.00 (L0003)
5/16" SQ x 2 1/2" Long	3	$13.00 (L0004)
3/8" SQ x 3" Long	2	$14.00 (L0005)
1/2" SQ x 4" Long	1	$11.00 (L0006)

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70-630 Double Ended Scriber

- 190mm hardened steel
- Features straight & 90° tips with knurled body

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70-631 Pocket Pen Scriber

- 150mm carbide tipped
- Diamond knurled for comfortable and secure grip
- Precision ground tungsten carbide scribe tip
- Includes pick up magnetic end

$17.60 (Q631)

Spring Calipers

- Divider – 150mm (Q634)
- Inside – 150mm (Q635)
- Outside – 150mm (Q636)

$8.25 EACH

LCD Display Units

- Resolution: 0.01mm/0.0005"
- Metric/Imperial conversion • Zero setting
- ON/OFF switch • LCD back-light display
- Magnetic back panel for mounting
- Includes: 2 metre scale connecting cables & 2x AAA batteries

2-Axis DRO $88 (M731)

3-Axis DRO $129 (M732)

NEW RELEASE

Precision Steel Square

- Hardened & polished spring steel blades
- True right angle inside and outside

Blade	Stock	
75mm	60 x 8mm	$24.20 (Q644)
100mm	75 x 11mm	$31.90 (Q645)
150mm	100 x 14mm	$36.30 (Q646)
225mm	140 x 16mm	$56.10 (Q647)

Steel Rules

- Metric one side / Imperial on the other side
- Rust & wear resistant for durability
- Rule graduations: 1mm, 0.5mm / 32nds & 64ths
- Made of hardened & tempered stainless steel with satin chrome finish

Size	Dimensions	
150mm / 6"	150 x 15 x 0.8mm	$5.50 (Q620)
300mm / 12"	300 x 25 x 1mm	$12.10 (Q621)
600mm / 24"	600 x 30 x 1mm	$17.60 (Q622)
1000mm / 40"	1000 x 35 x 1.5mm	$22.00 (Q623)

Aluminium Digital Scale Units

- Metric/Imperial conversion • ON/OFF switch
- With data output • Zero setting
- Scale can be powered by display unit
- Includes mounting bracket & LR44 1.5V battery

NEW RELEASE

Scale Type	Length	
Vertical	200mm	$37.40 (M733)
Horizontal	300mm	$46.20 (M734)
Horizontal	400mm	$56.10 (M735)
Horizontal	600mm	$74.80 (M736)
Horizontal	1000mm	$89.10 (M737)

(M733)

(M734)

Outside Micrometers

- Carbide measuring faces - painted cast frame
- Micro-fine clear graduations
- Measuring face 6.5mm, flatness 0.0008mm

Range	Accuracy	
0-25mm	0.004mm	$28.05 (Q102)
25-50mm	0.004mm	$35.20 (Q105)
50-75mm	0.005mm	$37.40 (Q107)
75-100mm	0.005mm	$56.10 (Q110)
0-1"	0.004mm	$27.50 (Q101)
1-2"	0.004mm	$35.20 (Q103)
2-3"	0.005mm	$37.40 (Q106)
3-4"	0.005mm	$56.10 (Q109)

Digital Outside Micrometer

- 0-25mm/0-1" range
- ±0.002mm accuracy
- 0.001mm/0.005" resolution
- Metric/Imperial conversion & zero setting keys
- Large LCD screen for easy reading

$74.80 (Q124)

NEW RELEASE

Outside Micrometers

- High accuracy interchangeable rods with hardened & micro lapped flat anvils provide a wide measuring range

Range	Accuracy	Type	
0-50mm	±0.004mm	Metric	$106.70 (Q145)
0-2"	±0.00016"	Imperial	$106.70 (Q145S)

Digital Calipers

- Accuracy DIN862
- Large clear LCD screen
- Metric/Imperial, zero setting at any position
- Splash proof electronic unit
- Four way measurement

Size	
150mm / 6"	$82.50 (Q180)
200mm / 8"	$106.70 (Q181)
300mm / 12"	$157.30 (Q182)

IP54

Bench / Pedestal Drills

- 20mm drill capacity
- 2MT spindle taper
- Micro switch on belt cover
- 16 spindle speeds
- 1hp 240V motor

SBD-25A Bench Drill $308 (Q144)

SPD-25A Pedestal Drill $352 (Q147)

SIEG X3 Mill Drill - Geared Head

- 2 speed gearbox
- 3MT spindle taper
- 0.75hp 240V motor
- 50mm face mill capacity
- Dovetail vertical slide
- Spindle lock for quill
- 550 x 160mm table size
- Travels: (X) 400mm (Y) 150mm (Z) 350mm

$1,529 (M153)

AL-60M Lathe Mill Drill Combination Package

AL-60 Bench Lathe:

- 550W, 240V motor
- Precision ground 'V' bed

$1,199 (L148)

HM-10A Mill Head Attachment

- Head tilts ±45°
- 2-speed gearbox

$517 (M151)

PACKAGE PRICE ONLY $1,650 (K160)

NORMALLY $1,991

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Publisher's Letter

Wind farms are now recognised as a serious health issue

Back in January & February 2010, I wrote consecutive Publisher's Letters on the controversial topic of wind farms. The first made the point that wind farms are no substitute for base-load power stations. It went on to state that wind farms can cause problems for the electric grid because wind power can be so variable. Because of that, every wind farm needs an expensive gas-fired open-cycle power station to back it up; if the wind drops, the gas-fired generators can be quickly brought on line to make up the deficit.

Energy companies love these schemes because while various government mandates mean that wind power must be accepted by the energy distributors at low tariffs (to make the wind farm a viable economic proposition), the gas-fired power is charged at much more costly "peak demand" tariffs. The consumer pays for all of this, of course, all in the name of "being green" and "doing something to mitigate carbon pollution". Whenever you see a large company or financial institution promoting anything to do with "being green" or being "carbon neutral", you can be sure there are sound commercial reasons for doing so and probably not out of love for the environment.

My second Publisher's Letter on the topic, in the February 2010 issue, highlighted the fact that wind farms are a blight on the existence of many people living in their vicinity. That was largely pooh-poohed by many people at the time, backed by surveys that basically concluded that "if you can't hear it, it is not a problem". Three years later, the picture has changed markedly. Now it is recognised that wind farms can make people sick and that they should not be located close to where people live; not within a kilometre or more, in fact. Furthermore, there have been judgements against new wind farm developments for the above reasons. And just recently, an Australian court has recognised the adverse financial impact of wind farms for neighbours, in that they do reduce property values.

Even worse, South Gippsland Shire Council in Victoria has agreed to cut rates for one landowner on the basis that his property would lose value because of an adjacent wind farm that is yet to be built. Other rural municipal councils are very worried about this concession, because it could have serious implications for their overall rate income.

All of which makes our project in this month's issue for measuring infrasonic noise very topical. It is cheap to make and yet can provide test results that previously would have required a suite of test equipment worth tens of thousands of dollars. Yes, we know that such results are probably unlikely to be accepted in a court action against wind farms but they would certainly provide grounds for much more serious investigation. Previously, local action groups have simply been unable to afford the expensive instruments and expertise that investigations into infrasonic energy from wind farms would require. Now, with our Infrasonic Detector project in this issue, they can afford to do some sound-based investigations.

Even if you have no interest in wind farms or do not believe that they represent any sort of a health issue, there are good reasons to have a look at this project because it can be used to investigate infrasound in a wide range of settings, in the home, in factories and offices and even in the wide open spaces. Want to investigate the infrasonic mating calls of a crocodile? Our Infrasonic Detector can do it. (Just make sure the crocodile does not come to investigate you!)

The Infrasonic Detector will be a great schools' project. It has the potential to introduce students to a lot of acoustic concepts, as well as featuring two simple PCBs that can be built within a class period. And if it helps stop a few wind farms getting built too close to where people live, so much the better.

Leo Simpson

MAILBAG

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask SILICON CHIP" and "Circuit Notebook".

Stopping texting in cars is not practical

Your technical solution of disabling a phone above a low threshold speed (Publisher's Letter, February 2013) seems to me to be totally infeasible, in that it assumes that anyone using a phone at above this threshold speed is the driver of a car. You have ignored the possibility that the user is a passenger in the car – and nobody has ever made any suggestion that the use of a phone by a passenger constitutes a significant danger.

Further, how about bus and train passengers? For that matter, I suspect that train drivers actually use phones while driving for operational purposes; trains do not require the detailed attention that cars do as no steering is needed.

The proposed technology also is a problem. For a start, there are a lot of "non-smart" phones in use that do not have a built-in GPS; my own is an example. After-market installation of any device as a condition of registration in all vehicles comes up against the problem that there are a very large number of different vehicles on the road. Any such installation would be far more expensive than justified by the results.

Although it seems obvious that mobile phone use is a major road safety issue, it is very difficult to find real-life data to support this. For example, consider that 15 years ago, mobile phones were rare but today they are ubiquitous and as you note, despite legislation, they are widely used by drivers.

If this represented a significant risk, you would expect the road death and accident statistics to reflect this. In fact, these statistics have continued to decline (as they have almost continuously since the start of their collection). Further, the USA provides useful data in that only some states have made phone use while driving illegal – and there is no significant difference in road accident statistics or trends between otherwise comparable states.

This makes it very difficult to accept that mobile phone use is a significant added risk. My suspicion is that the use of a phone is just one of numerous distracting activities that drivers undertake (eg, changing radio stations, discs or cassettes, eating, drinking, changing GPS settings, disciplining kids, adjusting sun-visors, talking to passengers, listening to the radio etc) and that any of these can cause accidents, just as readily as can telephones. I am reminded that my father would never have a radio in any of his cars as he regarded them as a driver distraction.

John Denham,
Elong Elong, NSW.

Comment: passengers using mobile phones in cars are a distraction to the driver, particularly if the passengers is taking the call on behalf of the driver. And how much lower might the number of road accidents be if drivers were not using mobile phones?

Be wary of government edicts on mobile phone use

Whilst I agree with the dangers of texting whilst driving, Leo Simpson's proposed fix doesn't appear to cover the issue of how to determine if the driver or a passenger is using the phone. I am also wary of technological fixes that require both phones and cars to be modified – especially if the fixes were specified by a government committee.

Peter Jeremy,
Killarney Heights, NSW.

Solid state vs valves: the debate continues

Any discussion around valves versus transistors always catches my eye

Gas hot-water losses lower than electric

I'm not going to comment on the comparative costs of gas and off-peak electric hot water. However, your comment (Mailbag, January 2013, page 10) that the losses from a modern storage system are small startled me. My own experience has been the opposite.

Thirteen years ago, we built a new house and installed a new (ie, modern) off-peak storage hot-water system. We did not have reticulated gas at the time and the off-peak storage system was certainly the best and most economical system. Due to my being retired, I started to read our meters on a weekly basis. Also due to being retired, we went away frequently on 2, 3 or 4-week trips.

At first I was turning the hot water service off and getting a neighbour to turn it back on the day before we were due back. That proved less than reliable and being greeted by no hot water after a long day's journey did spoil a few holidays. So I took to leaving it on.

That was when I became aware of just how inefficient the system was. The system used almost the same amount of electricity whether we used hot water or not. Even at the hottest times (when the losses would be least) the savings from using no hot water were never greater than 20%. Clearly 80% of the electricity used was going in losses from the system.

Eighteen months ago, the tank failed and as we now do have reticulated gas, we installed an instantaneous gas system. It may actually be more inefficient than its predecessor however it doesn't use gas when we are not here!

Geoff Syme,
Mildura, Vic.

Mailbag: continued

The quest for long term data storage

I am keen on photography and having long since converted from conventional chemical methods to digital, would like to know the best and most reliable method of storing digital data.

To the best of my knowledge, a number of photographic chemical images have survived for over 150 years. I am concerned that digitally stored images may become unreadable in a relatively short time. What is the best and most reliable method of long term digital data storage?

Hard disk drives are based on precision mechanics, and use magnetic data storage, and I suspect, cannot be relied on in the long term, particularly if a drive has been stored, and not run for some considerable time. Recordable CD or DVD blanks can become unreadable for a number of reasons, including low quality blanks, moisture or excessively high storage temperature and insect or bacteria attack damaging the surface. I have personally seen the results of all three causes.

For USB, good quality "memory sticks" are readily available for as little as $0.60 per gigabyte, possibly offering an economical long term data storage method. To the best of my knowledge, they rely on voltages stored on tiny internal capacitors, for their data storage. But how long will a memory stick retain its data?

I have considered storing each memory stick carrying data in a plastic zip bag, together with a small satchel of silica gel, to keep the moisture level low. I have contacted several manufacturers of memory sticks for information but have so far not received any answers. I would be most interested in suggestions and feedback from SILICON CHIP readers will be most welcome.

Poul Kirk,
South Guildford, WA.

the difference at "normal to loud" listening levels. I am somewhat surprised to have to admit that.

I am sure if I were to overdrive and induce clipping, the valves may sound more pleasant as I have experienced in building guitar amplifiers but for normal listening I find they are the same.

That is where the logic ends though. The emotional side of me enjoys the building of valve amplifiers and I like playing vinyl records. The warming up and the warm glow of the KT88s provides an added unmeasurable degree of pleasure to the music; very unscientific but there it is.

Another point of comparison, I would love to see a blind and instrument test of some interconnect and speaker cables. I find it interesting in hifi magazines where there are no test instrument measurements, just talk of wide sound-stages etc. Like my amplifiers, I make up my own interconnects and if there is a cable that is measurably better than another one I would be keen to try it out.

Geoff Healey,
Dandenong North, Vic.

Comment: we suspect that if hifi magazines ever did blind testing of interconnect cables, whether for signal or speaker cables, there would be no discernible difference.

Distorted valve sound is not art

Phil Wait's concept of comparing the use of a valve amplifier to looking at a Norman Lindsay painting is totally inaccurate (Mailbag, page 4, February 2013). A Norman Lindsay painting is the source art work in the exact same way as a Pink Floyd recording is the source art work. In both cases, the source art work is alluring and mystical and in both cases I would want nothing between me and that source.

If you are unable to see the original Norman Lindsay painting then you will have to be satisfied with a reproduction. I would want that reproduc-

tion to be as good as possible to let me appreciate the original colours and brush techniques of the artist. I would not be happy with a sepia photo of the original.

It is the same with music. I want as close as possible to the original sound created by the artist, with nothing added and nothing taken away. I do not want a distorted valve sound that is the audio equivalent of a sepia photo.

Laurens Meyer,
Richmond, Vic.

Salvaging equipment affected by flood waters

I have a bunch of equipment such as a desktop PC, LCD monitors, routers, amplifiers and pro audio equipment, including cables, musical instruments, synthesisers and microphones etc, plus other stuff that has been flood-affected by the floods in Bundaberg recently.

As an amateur and hobbyist, I would like some professional/expert advice on the possibility of salvaging some of this equipment. Can these items be cleaned and possibly returned to service? All this was in storage and was uninsured. I do not have the money to replace all of this gear, so anything I can save is important to me.

I realise that the surround sound speakers are ruined (cabinets and cones) but will the rest of the gear be written off? I don't have the money to have a serviceman look at all of the stuff on the chance it might be saved but I am competent enough to attempt some recommended procedures myself. Will it be simple stuff like PC keyboards and microphones that have a better chance? Will transformers and ICs trap the silt and make it unwise to power up, even after careful cleaning?

I also have a collection of over 1600 DVDs. Obviously the case inserts will be ruined but is the media itself waterproof enough to survive, at least until I can copy all the movies to a Media Server NAS Raid Array and save the content?

I imagine that many others are in my situation and would also appreciate any "tech support" in these issues. Comprehensible and reliable information is not exactly freely available and that is what I trust SILICON CHIP for – reliable, comprehensive and no bull.

David Kovin,
via email.

Comment: we did an article on this very topic in June 2011, after the

A power saving device that does work!

Recently an electrician mate turned up with a device which he reckoned would save electricity. I said I'd look at it. All it consisted of was a toroidal auto-transformer; actually a 240VAC to 25V, 6A transformer connected as a step-down unit.

As the 240V winding had less than 220V on it (this being the output winding), the magnetising current was only 8mA – a continuous loss of some 2W. However, the effect on the load did seem to be worthwhile. As the mains voltage here seems to be in the 245-255V range (possibly due to so many grid-feed solar systems), the drop to 220-230V really helped.

The 10% voltage drop gave 10% current drop for motors. With incandescent globes, there was only a 5% current drop but at least they'll last longer.

To check things out further, I grabbed the 20A Variac and observed the current change in the compressor on my fridge. The minimum current consumption was at 184V. Below 184V, the current increased – too much armature lag but the compressor wouldn't start dependably below 200V.

So there you are, given a voltage drop of 15% and a current saving of 7.5-15%, there SHOULD be a power saving of some 25%. Of course, if you have to pay "through the nose" for your toroidal transformer, it's going to take you years before you actually break even; even at these new inflated carbon-taxed electricity rates.

Bob Yorston,
Roseville, NSW.

Mailbag: continued

LED down-lights installation precautions

I was delighted to see the LED down-lights article in the February issue. However, I was disappointed that you did not stress the need to cut all power to those transformers and lights which were to be replaced before any work on them was undertaken.

With respect to the problem of nicely cutting the larger hole, what is needed is a circular piece of wood which is smaller than the desired hole and which has a central hole for the drill bit. This piece also needs a centred piece which fits into the original hole and is drilled for the pilot drill and screwed underneath the circular piece. Then screw all that to the piece to be removed and Bob is your uncle. The items can be reused.

I think we will have to wait a while for winter to come and the prices to drop before venturing into replacing the halogen down-lights in a house we own, much as I detest them.

Brewster Ashley,
Mawson,ACT.

Comment: on the point of disconnecting the power to the transformers and lights, there were two reasons why we did not. First, each light has its own 3-pin mains socket (normal practice, these days) and so it is quite safe to disconnect each transformer by simply unplugging it. Second, it was impossible to see anything in the ceiling void without relying on the light leakage from the back of the halogen lamps.

We like your method for cutting larger holes. It is much cheaper but of course, it doesn't avoid any of the mess.

In practice, we think that a lot of people will simply opt to change to MR16 LED replacements, provided that they are using iron-cored and not "electronic" transformers. That way there is a still a substantial saving and it's a simple changeover.

Queensland flood disaster of that year. You can access it on our website at ***www.siliconchip.com.au/Issue/2011/June*** *or you can order a back copy. Your DVDs should be OK but the printed inserts will be mush.*

Digital TV can work with reflected signals

The discussion on digital TV reception is very interesting to me. We live in a valley almost entirely surrounded by hills that block virtually all analog reception but since the introduction of the digital service a few years ago, most people in the valley have discovered that direct off-air reception is now possible. The digital signal is usually of good "strength" and reasonable "quality" as read off the installing page of the set-top box and while it normally operates well, it is easily upset by heavy rain which can stop all reception.

There are two repeater sites that may be available depending on one's location in the valley, at Mount Tamborine and at Currumbin. These are the same sites that currently, for a few more months anyway, carry the old analog service as well.

Now the strange thing is that virtually no two antennas in our area are pointing in the same direction! Ours, for instance, points in the general direction of Currumbin but next door's points about 180° opposite, roughly towards Mount Tambourine, while next door but one points about 90° to ours at nothing in particular. Some of these antennas have been installed by professionals and some by the owners (like ours). I suspect that most people determined the correct place to point the antenna beforehand (as I did) but when it was installed in that position the results were poor or non-existent, so the antenna was simply rotated for best results.

Could the explanation be that we are receiving a reflected signal from the hills? I know in the analog days this would have resulted in an usuable picture but maybe the digital service can operate like this. Is there data included in the signal that shows the origin, ie, which repeater you are using?

As a side note, we were able, after an exhausting amount of paperwork, to get the VAST service, as our area is a "designated black-spot." We can use this if the antenna does not work but we often get trapped by the dreaded daylight saving, as of course Queensland does not tamper with God's time.

We find the VAST box OK but it has a few shortcomings that could probably be easily fixed. These include: (1) the hard disk runs continuously, even if the box is switched to standby; (2) the box outputs a black signal when switched to standby which prevents the TV's blue screen coming on, resulting in the TV being left on inadvertently; and (3) it will display subtitles

Issues Getting Dog-Eared?

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live but will not record them. It seems a software revision could fix all of these problems easily.

Bryce Templeton, Bonogin, Qld.

Use boot-lace crimps for down-light connections

I have a couple of comments on the February 2013 issue which is as good as ever.

First, with respect to the article on LED down-lights, you are not permitted to tin wire for connections as the solder will creep; it moves under the pressure of the screw terminal, even with good terminal blocks. The terminal does not even have to be warm or hot, as it would be in a non-LED type of fitting. You should use "bootlace" crimps or similar. The relevant regulation is in the Australian wiring stands, AS3000:2007 Clause 3.7.2.7.

It looks like they have relaxed the requirements a little bit but it does clearly state "shall not be clamped under a screw or metal surfaces" so that eliminates most of the connectors I know of. It may allow the use of the spring type of connector – but that is still between "metal surfaces" so I guess not.

Suitable bootlace crimps are available from Jaycar Electronics.

Second, with respect to battery charging (Ask Silicon Chip, page 90), a bench power supply can be used to charge the SLA battery but a diode should be fitted in series to prevent the SLA battery voltage taking out the power stage in the PSU. The downside is that the voltage now needs to be measured at the battery terminals.

I use the current limit on the PSU to prevent overcharging and this works a treat. I use this to charge many different voltage batteries (or battery sets), from a humble 12V SLA to a 240V battery pack we use for starting turbines. But all power supply units have that series diode.

For the 240VAC pack we use a Lambda 600V 2.5A bench PSU which works fine – with a diode.

Mike Abrams, Capalaba, Qld.

Magazine collection needs a good home

I have numerous "Electronics Australia" and Silicon Chip magazines collected since the early 1990s until 2008. This includes a large plastic tub full of magazines and three lots of magazines bound in custom EA binders. They are all in pretty good condition.

I would be happy to give these free to any reader who wants them. I can be contacted by phone at 0412 015 889.

Mikel Duke, via email.

Remote homestead 32V DC power

I was wondering if any of your contributors or readers could provide information on a bygone era of power generation for remote homesteads, namely, 32V DC power.

Having lived on a number of cattle stations in central western Queensland, these power systems were com-

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Mailbag: continued

Power savings in pool pumps

The comments by Trevor Krause of Gympie in the Mailbag pages of the December 2012 issue were thought-provoking and interesting. I generally agree with all his statements on the operational curves of the pumps, the efficiencies of the speed controller and the prowess of the pump designers etc except for the conclusion of his letter.

I believe that in the practical operation of a pool system there are power and time restraints that need to be operated within.

The pump needs to be powerful enough to operate the pool cleaning system, be it the vacuum hose or a creepy crawly. As such, this is the highest demand for the pump generally.

There is also a need to turn over the volume of the pool water at least a couple of times a day to ensure the water is filtered and kept clean. However, most importantly, there is a time-dependent aspect of the pool pump operation in operating the salt-water pool chlorinator (in the case of a salt-water pool). This needs to be operated for a number of hours per day to ensure the pool will get the required dose of chlorine.

The time is dependent on the size of the chlorinator relative to the pool, the salt content and the calibration of the chlorinator. This is time dependent and the flow can be minimal.

Therefore, the people that design a pool system provide a pump that is the best compromise that suits the sum of all the requirements; requirements that are sometimes conflicting. We require a pool pump powerful enough to operate the cleaning system, voluminous enough to turn over the required pool volume and operated long enough to ensure the correct amount of chlorine is created.

The pool speed controller does well in throttling down a powerful enough pump that can clean the pool to an economical level of operation that will turn over the required volume of water and operate the chlorinator for an adequate length of time. The pump can then be operated at full power when required for cleaning or other needs.

For a pool system, this is a good compromise; it reduces running costs significantly for no operational disadvantage, albeit it at some loss of efficiency.

My preferred option is the installation of two pumps; one rarely used for cleaning but operated daily for filtering (water turn over) on a reduced cycle and another low-powered, low-cost pump that is constantly running that operates through the pool chlorinator. This low-powered pump is sized to provide constant flow, hence the pool has a consistent level of chlorine and the pump runs efficiently at full design speed. The added advantage is that the chlorinator can then be down-sized as it operates for more hours in the day.

Charles Camenzuli,
Wentworthville, NSW.

monplace until the 1980s. Typically, the generation system consisted of an engine, generator, switchboard and battery bank.

Our system was driven by a single-cylinder, water-cooled (non-pressurised) Southern Cross diesel engine with a large flywheel. The Southern Cross engine and generator were manufactured and sold as a set by Toowoomba Foundry Pty Ltd.

Over a 74-year period, many models of engines were produced, as were the generators, which were mainly rated at either 1kW or 1.5kW. Lister diesel engines were less common in my experience.

To assist start-up, the cylinder was lubricated with a cap-full of oil poured through an opening from a container whose base doubled as the oil-hole screw-top. Cranking was mostly done manually. However, some systems had an electric start whereby the generator was temporarily operated in DC electric motor mode, deriving its source

from the battery bank. In either case, when maximum cranking revs were reached, a compression lever was engaged on the engine, allowing it to fire.

The engine was attached to the generator either by a direct drive shaft or a belt and pulley configuration. Most systems were direct-coupled so that the engine had to be cranked in unison with the generator. However, some engines had a clutch which disengaged the generator until optimum operating speed was reached.

The switchboard was either fixed directly to the top of the generator or located on a nearby wall. In my experience, the former arrangement tended to be more troublesome as the vibration resulted in loose terminal connections. Generally, the switchboard housed a voltmeter, ammeter, fuses, isolation switch and electric-start switch. The battery bank consisted of 16 2V batteries connected in series to provide the necessary 32V supply. Each 2V battery was about the size of a car battery.

This arrangement resulted in a power supply that enabled the use of lights and small appliances, literally at the touch of a switch day or night without the need to start the engine. However, when larger appliances were used or when the current drain increased with more lights being used at night, it was necessary to augment the battery bank with generator current.

It is interesting to note that there was a reasonable range of appliances developed for the 32V market. The light globes were the standard bayonet-type with a 40W rating. The appliances that I encountered (with brand names) were a wringer-type washing machine with agitator (Simpson), iron (Hotpoint), 2-brush floor polisher (General Electric), mixers with attachments such as a juicer & mincer (Sunbeam), a constellation-type vacuum cleaner (Hoover), and a 3-speed oscillating desk fan (Elcon). The electric iron had no thermostat, requiring the user to adjust the temperature by manual switching.

These appliances were mostly fitted with standard 3-pin plugs as per 230V, with the earth pin being unused. The iron and washing machine required a special 2-pin (thick rounded) plug to permit heavier current (this was before the adoption of the Australian Standards low voltage 2-pin T-type plug).

The generation system and appliances were generally quite reliable, with few breakdowns. When repairs were needed, they were often carried out by local electricians who were multi-skilled as auto-electricians and armature re-winders. This combination of power supply and appliances made life relatively comfortable in remote rural areas; indeed, being non-reliant on the power grid contributed to a sense of autonomy. However, as rural homesteads gradually became connected to the expanding power networks, these power systems fell into disuse and were consigned to the scrap heap.

In closing, I wish to suggest that there may be readers or contributors who can supply some of the more technical details and specifications of these systems. Others may be able to supply additional information regarding their preservation.

Mark Fry,
Toowong, Qld. SC

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Got an iPad? Turn it into something really useful with this trio of test instrument add-ons

Oscium test add-ons for the iPad

By LEO SIMPSON & NICHOLAS VINEN

Until now, iPads and similar tablets have really only been useful for a limited number of "media consumption" uses such as reading PDFs and web browsing. But increasingly they can be used for tasks such as remote accessing of instrumentation and control systems via WiFi. Now there is a suite of tiny accessories to turn an iPad into one of several powerful test instruments.

SAY YOU ARE a field service engineer and you regularly go on-site with nothing more than a multimeter and your iPad to access various control systems in a commercial building or a factory. The iPad records all the essential data you need, allows you to make adjustments to systems on the go and can be used later for reporting, billing and so on. Great. But every now and again you might have to get serious and break out some test gear to make in-depth measurements.

At that point the iPad is not much help at all but now it can be. How would you like to be able to do some spectrum analysis in the 2.4GHz UHF bands? Or maybe you need a 16-channel logic analyser to debug some tricky intermittent fault? Or maybe you need a mixed signal oscilloscope which can look at analog signals as well as digital?

Previously, to do those tasks you would need some fairly bulky instruments and the chances are that they would all need a 230VAC supply since such instruments can rarely run on battery power. Now though, those three instruments are available for the iPad, iPhone and iPod Touch. They come from Oscium and each is a dongle which simply plugs into the dock connector and is powered from the "iWhatever's" internal battery.

Obviously you also need an "App" to drive them and these are available free from the iTunes store. So all you have to do to turn the iPad into, say, a logic analyser is plug in the dongle, connect the cables and tap the icon to launch the software.

Spectrum analyser

The WiPry-combo is a spectrum analyser covering the 2.4-2.5GHz range with a dynamic range of 52dB and a sensitivity of -40dBm. Up to 28dB of input attenuation can be selected,

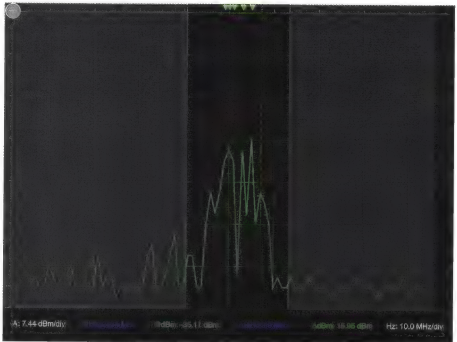

Fig.1: the WiPry in peak-hold/"decay" mode showing WiFi activity on channel 6. The grey masking on either side shows which frequencies are outside the currently selected channel although this can be hidden. Other modes such as Heat Map (shown in the lead photo) and Waterfall give a different display.

to allow a maximum input level of +40dBm. Its resolution bandwidth is 1MHz. Input is via an SMB connector and a 2.4GHz stub antenna is provided which gives reasonable results. Sweep time is 200ms and the screen update rate is about 1-2Hz.

The software gives you a number of modes including raw, decay, averaging, peak hold and waterfall. There is support for cursors and markers. The cursors can be set on either side of the WiFi or ZigBee channels to make it easier to work out which channel a given peak falls in.

We found that the WiPry works best when set to Decay mode with a peak hold time of three seconds and a decay rate of 4dBm per second (see screen grab). It's also a good idea to turn the iPad's WiFi off so it doesn't interfere with the readings. In this mode, you get a series of spikes or a plateau in each channel where a WiFi network is present and you can use the channel mask feature to check which one corresponds to that range of frequencies.

The WiPry is quite handy for optimising WiFi networks as it lets you see which channels are being used by your neighbours and select one for your own network which doesn't interfere (adjacent channels overlap in frequency). Our own WiFi network was on channel 6 (a common default) and somebody else nearby has one on channel 5.

By switching ours to a higher numbered channel, we managed to both reduce the power required to communicate on our network (as demonstrated by lower peaks in the WiPry display) and also, in theory at least, increased the speed due to less corrupted or lost packets. So clearly the WiPry has some real applications and it's also the cheapest of the three add-ons we're reviewing here.

Judging by the name, the WiPry is intended to allow users to "sniff" for wireless networks and see where they are, what channel they are on and so on. Based on our experience, it certainly should be suitable for that sort of task too.

One minor limitation of the WiPry is that it will only run in landscape mode, ie, it doesn't rotate if you hold the iPad in portrait. Obviously the horizontal frequency axis would be more compressed in portrait mode but it's sometimes more comfortable to hold an iPad that way and it also means that you can't use it with the antenna pointing at the sky.

Mixed signal scope

The iMSO-104 is a scope interface with one analog channel and four digital channels. It is roughly the same size

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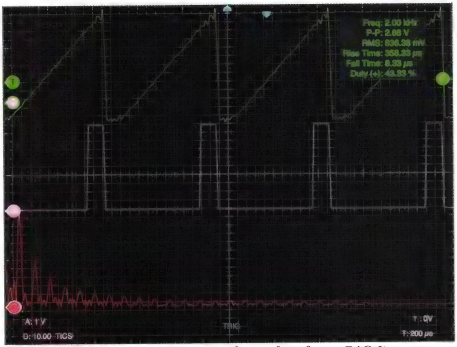


Fig.2: the iMSO being fed a 2kHz sawtooth waveform from a DAC. Its bandwidth is good enough to pick up the "wiggles" from the delta-sigma algorithm being used. An FFT of the waveform is shown at the bottom in red while the mauve trace shows one of the logic channels, fed from the same signal.

and weight as the other two Oscium accessories, ie, very small and light. While the analog bandwidth is limited, it's certainly good enough to check low-frequency waveform shapes as you may need to do from time to time.

For the analog input, you get a proper 10:1/1:1 switchable probe although it has a very short lead which can be awkward when making connections to equipment. The probe plugs into the iMSO-104 using an SMB connector. This can be used to measure signals up to ±40V in 10:1 or ±5V or so in 1:1 mode. Vertical sensitivity is adjusted in six steps using a similar two-finger gesture as is normally used to zoom the display in or out.

The maximum sampling rate is 12MHz and analog bandwidth is stated as 5MHz although if the probe is set to 1:1 then it will be considerably less.

For digital signals, the four logic channels connect via separate wires that join at the unit in a JST-style connector. At the other end you can attach the provided "grabbers" which can be hooked to component leads, IC pins etc plus a ground point. These work with 3.3V or 5V digital signals (possibly lower; they do not specify).

The software offers the basic features of a scope. You can adjust the timebase between 2µs/div and 1s/div (with a similar gesture as for adjusting vertical sensitivity). The vertical sensitivity for the analog channel can be adjusted between 500mV/div and 20V/div in 10:1 mode. It can be triggered on a rising or falling edge with adjustable threshold and holdoff. The screen updates about once per second.

As you would expect for a mixed-signal scope, automatic measurements can be made on the analog signal including frequency, period, peak-to-peak voltage, RMS etc. We quite like the measurement interface since you can show up to six at a time and they don't take up a lot of space, sitting in the top-right corner of the screen.

The digital/logic inputs are a rather basic affair with no serial decoding or anything like that but they will let you observe one to four control signals up to a megahertz or two, along with the analog waveform.

There is also an FFT feature which could come in handy for analysing certain analog signals although the relatively low overall bandwidth makes this of limited use. However, this does illustrate another good feature of the Oscium instruments which

is that they can deploy new features via software upgrades after you buy the product; apparently, the FFT function was not available with the original software package.

The "App" is also able to update the firmware in the dongle itself, as we found out the first time we plugged it in. This was a quick and painless process although we aren't sure what exactly the update fixed.

Regarding the analog probe lead, being only about 50cm long means you'll have to plan ahead in terms of routing cables and so on (the logic probes are similarly short). If you put the iMSO unit on the left of the iPad and whatever you're testing on the right, it won't reach!

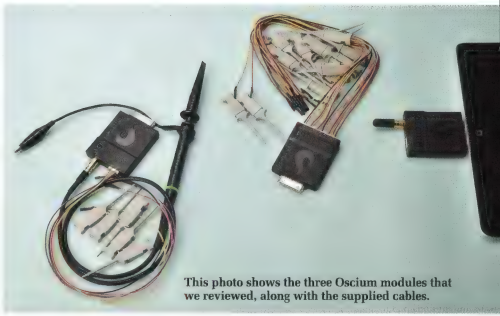
We're not sure if the lead could be extended without affecting the probe compensation too badly but unfortunately, the use of the SMB connector rules out the use of standard probes with longer leads (without an adaptor, anyway). By the way, the iMSO comes with a plastic compensation adjustment tool to turn a trimpot on the unit. The manual describes the procedure which is a bit fiddly as the adjustment is very sensitive; they say that it comes pre-calibrated but it's worthwhile checking it anyway and then you can make an adjustment if necessary.

Overall, this is a rather basic mixed signal scope but it's quite good considering that if you are already carrying an iPad, you wouldn't even notice the extra hardware which can be slipped into a pocket in a bag and then pulled out when you need it.

Logic analyser

The LogiScope is another Oscium iPad accessory and this one is a 100MHz, 16-channel logic analyser. Each channel is broken out into one of two small 10-pin headers on the end of the unit and connections are made using a similar arrangement to the digital channels for the iMSO-104. Besides having more channels though, the LogiScope also has serial protocol decoding capability.

The LogiScope can decode logic-level serial (RS-232, etc), SPI, I^2C and generic parallel buses. The default display shows the 16 channels separately but you can enable serial decoding by selecting the mode, mapping each signal to one of the inputs and then configuring some options such as clock polarity and so on, which are specific to the mode. The decoded data then appears below the raw signals in the timeline.



This photo shows the three Oscium modules that we reviewed, along with the supplied cables.

Signal voltage levels supported are 2-5V and the data buffer is 1000 samples long. It can decode serial up to 921.6kbps, all standard I^2C speeds and SPI up to 25MHz. Bandwidth for a square wave is quoted as 30MHz.

The trigger system is quite advanced, supporting up to four complex triggers which can be based on the positive or negative edge of a single line, a decoded serial value, pulse width, I^2C packet property (address, data or length) or SPI packet length. Triggers can also be delayed and sub-triggers are supported, ie, it can be triggered when one specific event is followed by another within a certain time.

That makes it a quite capable logic analyser, especially when used with an iPad or other device with a large screen. And despite being the most expensive of the three Oscium iPad accessories that we are reviewing, it is the one that we would be most likely to purchase. While there are cheaper, PC-based logic analysers with similar capabilities, unless you already carry a portable computer with you, they are far less convenient.

Conclusion

For each of these devices, it is possible to save or email a screen grab for later review which is quite handy. It's how we captured the screens shown in this article.

One limitation which we ran up against is that since these accessories use the dock connector, you can't charge the host device while you are using them. That's understandable, given that the iPad and iPhone really only have the one connector (ignoring the audio jack, which is sometimes used to interface to certain peripherals). But it does mean that if your battery is running low, your test and measurement session may have to be curtailed.

The build quality of the units seems good. The plastic cases are translucent and various surface-mount ICs and passive components can be seen through them.

In conclusion, while the performance of these accessories cannot fully replace the equivalent separate instruments, they are very convenient to carry if you already have a suitable host device. They are also quite easy to use and we didn't really run into any problems installing or operating the software.

So if you are rarely separated from your iPad and like the idea of carrying a mini electronics lab around in your pocket, these could be just what you need. While you can use them with an iPhone or iPod Touch, with such small screens you might find them of more limited use.

The WiPry-combo is $199+GST, iMSO-104 $299+GST and the LogiScope is $399+GST (freight is extra).

For further information, contact Emona Instruments. They can be reached at (02) 9519 3933 or via their website at **www.emona.com.au** or via email at **testinst@emona.com.au** SC

CLASSiC DAC Pt.2

Build it & get better sound from your TV, DVD/CD player or set-top box

Last month, we introduced our new CLASSiC DAC which has three TOSLINK inputs, three S/PDIF inputs, a USB input, SD card playback and is based on a Cirrus Logic CS4398 DAC chip. Unless you have absolute top of the line equipment, the CLASSiC DAC will improve audio performance and eliminate him loops which can occur when using analog inputs in a multi-source system.

TO SUMMARISE the most important features of our new DAC design, it supports sampling rates up to 192kHz, has a built-in hifi headphone amplifier, seven digital inputs including USB from a PC, plays WAV files from an SD card at up to 96kHz/24-bit resolution and has LED indication of the current sampling rate. It is powered by an AC plugpack so no mains wiring is required and fits into a slimline instrument case with custom front and rear panels.

While the double-sided PCB is quite compact, the circuit is quite large. This month we will describe it in detail, as well as presenting some performance graphs and data.

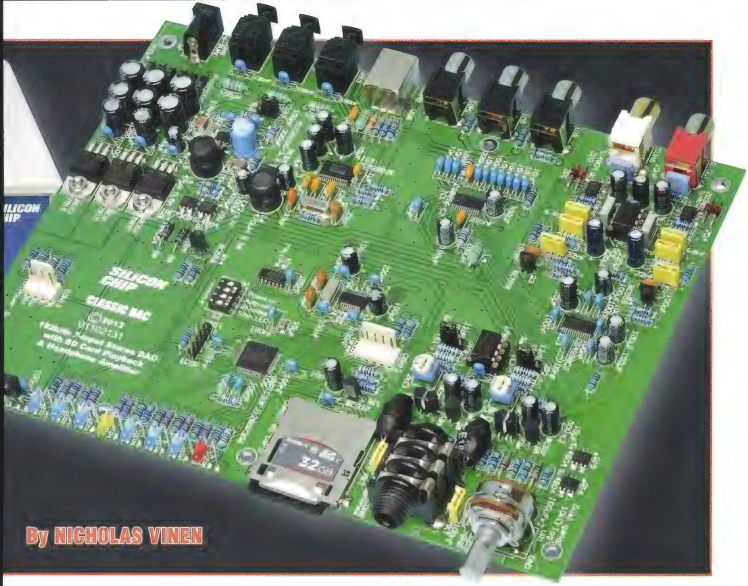
Circuit description

The circuit for the CLASSiC DAC has been split up into four diagrams. Let's start with the digital audio receiver portion, shown in Fig.4.

At left are the seven digital audio inputs. The first three are TOSLINK inputs which convert light pulses on optical fibres into a square wave output, available at pin 1. These signals are AC-coupled to inputs 4, 5 and 6 of the CS8416 digital audio receiver (pins 10, 11 & 12). These inputs are shown as 1-3 by the status LEDs and are at the left rear of the case.

As mentioned last month, the CS-8416 has internal input amplifiers which provide a DC bias level so we can simply AC-couple the outputs of the TOSLINK receivers to it.

The TOSLINK receivers contain high-gain, high-bandwidth amplifiers which can be upset by power supply



noise. As a result, the power supply for each is isolated using a 100µH RF choke and bypassed by a 100nF ceramic capacitor.

Power comes from the 3.3V or 5V rail, depending on what type of TOSLINK receivers are fitted and this is selected using link JP1. The micro uses P-channel Mosfet Q13b to switch off this supply (by switching off the ±15V rail) when the unit is in standby.

The three S/PDIF inputs are numbered 5-7 and connect to inputs 1, 2 and 3 of IC1 (pins 3, 2 & 1). Each has a 75Ω termination resistor to set the correct input impedance and the signals are coupled directly to IC1 via 10nF capacitors. The signal level is typically 0.5-1V peak-to-peak and the CS8416's internal amplifiers boost it to 3.3V to suit its decoding circuitry.

USB audio

CON5, a full-size Type-B socket for connection to a PC, is the USB audio input. The USB signal is decoded by IC2, a PCM2902E USB digital audio receiver chip. It has minimal support components, mainly consisting of bypass capacitors. 10µF capacitors are connected between IC2's analog inputs and ground so that should your computer be set up to monitor the inputs, you will get silence rather than noise.

The USB GND (shown with a different symbol) is not directly connected to the circuit ground; it is joined by a 100µH axial RF choke (L7) which prevents high-frequency ground noise from the USB line from coupling into the DAC.

IC2 connects to the USB signal lines via 22Ω series resistors, to set the correct line impedance, plus a 1.5kΩ pull-up to indicate its presence to the host PC. A 12MHz crystal provides the USB clock. The PCM2902E is powered from USB 5V, with an RC filter (2.2Ω/1µF) to limit the in-rush current and provide a degree of supply rail filtering.

When a PC is connected and playing audio, IC2 transmits S/PDIF data from pin 25 (Dout). Like the other S/PDIF signals, this is coupled to IC1 via a 10nF capacitor, in this case to its input 0 (pin 4). However, it is numbered input 4 on the front and rear panels.

We have also connected IC2's digital input (Din, pin 24) to the GPO0 output of IC1 via a 470Ω resistor. We can configure GPO0 to transmit the signal from another input. This may be useful for monitoring or recording from one of the signal sources without having to unplug it from the DAC and connect it directly to the PC.

The series resistor prevents damage to IC2 if USB power is not present, limiting the current in such a condition to 7mA peak and 3.5mA RMS. In practice though, we turn off the GPO0 signal when IC2 is not active. Note that the protection resistor forms a low-pass RC filter in combination with the Din pin capacitance but the corner frequency

The rear-panel view of the CLASSiC DAC. There are three TOSLINK (optical) inputs, a USB audio input, three S/PDIF (coaxial) inputs and two audio output sockets. The power socket (to connect a 9VAC plugpack) is at far right.

is high, allowing the S/PDIF signal to pass through unaffected.

The SSPND-bar output of IC2 (pin 28) indicates whether it is powered and connected to the PC. A 1MΩ pull-down keeps it low when IC2 is not powered. When it goes high, the DAC automatically switches to the USB input.

IC2 supports a maximum sampling rate of 48kHz. If the selected input has a higher sampling rate, the computer cannot monitor or record the audio. If you want to play back audio with a higher sampling rate from your PC, you must have a capable sound card with its digital output connected to one of the other inputs.

Digital audio receiver chip

Digital audio receiver IC1 is powered from the 3.3V rail, with its analog voltage at the VA pin (pin 6) filtered using a 100µH RF choke and parallel 100µF and 100nF capacitors. The analog pin powers its internal phase-locked loop (PLL) which recovers the audio clock rate. It's important that this supply is quiet and ripple-free for low clock jitter and thus low audio distortion.

The PLL filter components are connected between the FILT pin (pin 8) and analog ground (AGND, pin 7). We are using the recommended component values to suit the widest range of sampling rates, ie, 32-192kHz. The VA supply bypass capacitors are also connected directly to AGND.

The digital supply pins (VL & VD, pins 21 & 23) share 220nF and 100µF bypass capacitors. The 47kΩ pull-up resistor at pin 26 (SDOUT) sets IC1 into software-controlled control mode while a 100kΩ pull-down on reset (RST-bar, pin 9) disables the chip until the microcontroller is ready and pulls RST-bar up.

Note that IC1's eighth input, RXP7 (pin 13), is connected to the microcontroller (shown elsewhere) via a capacitor. It receives audio on this input from the micro when it is playing WAV files from an SD card, via a track labelled SPDIFO.

Regardless of which input is active, once IC1 has received and decoded the digital audio stream, it produces an I^2S (inter-IC sound) serial output on three lines: audio signal data (SDOUT, pin 26), bit clock (OSCLK, pin 27) and sample clock (OLRCK, pin 28). These are routed to the DAC IC, which we will look at later, using tracks labelled DASD, DABCLK and DASCLK respectively.

IC1 also generates a master clock at RMCK (recovered master clock, pin 24). This is at a fixed ratio to the bit clock of either 128 times or 256 times, depending on how it is configured. Virtually all oversampling DACs require a master clock to run their internal digital circuitry.

IC1 has a clock input, OMCK, which can be used for various purposes. We are using it as a reference clock; IC1 can calculate the ratio of OMCK to RMCK and this allows the microcontroller to determine the sampling rate of the incoming audio stream. We'll explain how the reference clock is generated later.

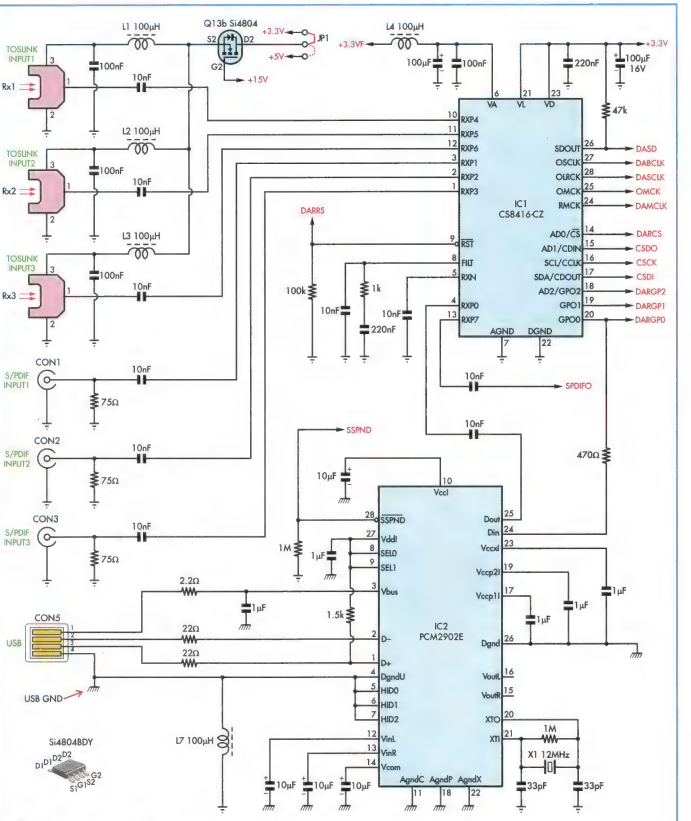
The remaining pins on IC1 are used to control it. Specifically, there is an SPI bus which the micro uses to read and write its internal registers, comprising CSDO (data to IC1), CSDI (data from IC1), CSCK (bit clock) and DARCS (chip select).

There are also three general purpose output (GPO) pins. As mentioned, GPO0 is used to send digital audio data to the USB interface. GPO1 and GPO2 are connected to the microcontroller and are used to signal any errors or changes in the audio format. They also allow the micro to monitor the state of the unselected inputs, which it can do by routing the signal, one input at a time, to a GPO pin.

Digital-to-analog converter

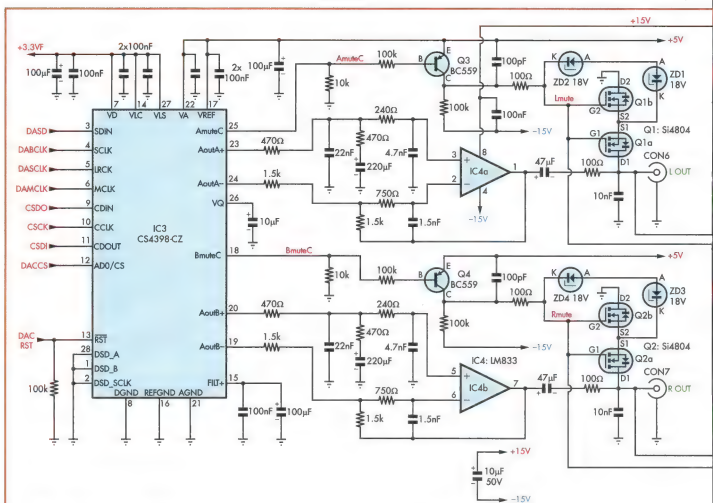
Now take a look at Fig.5, which shows the DAC circuitry at left and the headphone amplifier on the right. The I^2S audio signals are fed into pins 3-6 of IC3, the CS4398 DAC. Digital audio serial data (DASD) goes to SDIN, the bit clock (DABCLK) to SCLK, the sample clock (DASCLK) to LRCK and the master clock (DAMCLK) to MCLK.

IC3 shares the SPI control bus with IC1, ie, CSDO, CSCK, CSDI are connected in parallel while DACCS is its dedicated chip select line from the micro. Only one chip select line



SC 03/13 CLASSIC DAC DIGITAL AUDIO RECEIVER SECTION

Fig.4: the digital audio receiver circuit of the CLASSiC DAC. It has seven digital inputs (three TOSLINK, three S/PDIF & one USB), shown at left. Six of these feed directly into digital audio receiver IC1, while IC2 is required to convert USB audio to S/PDIF before IC1 can decode it. IC1 outputs I²S serial audio data on the five lines shown at upper-right while communications with the microcontroller is via the seven pins below them.



CLASSIC DAC DAC, LINE OUTPUT & HEADPHONE AMPLIFIER SECTIONS

Fig.5: the I²S serial audio data stream is fed into DAC IC3 and the resulting analog signals are filtered by dual op IC4 and associated passive components. IC4a & IC4b then feed the line outputs, CON6 & CON7. Dual Mosfets Q1 & Q2 provide output muting. The headphone amplifier shown at right is based on dual op amp IC6 plus six transistors. It has a selectable gain of 0dB or 12dB. The output signal is fed to headphone socket CON8 via two RLC filters to ensure stability.

is pulled low at a time so the other chip ignores any data on the bus. As with IC1, the micro controls the reset line which is pulled low by a 100kΩ resistor, disabling the DAC until the micro is ready.

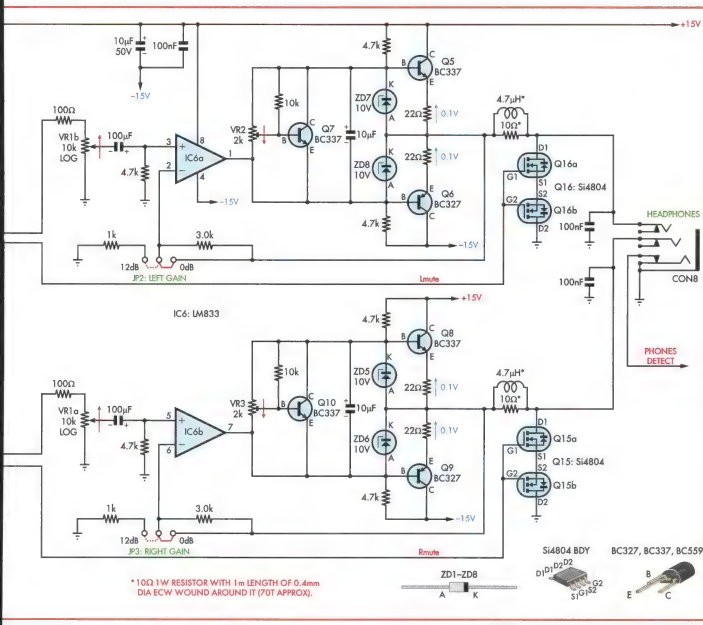
IC3 has a 3.3V supply for its digital circuitry and 5V for analog. The "3.3VF" supply is derived from the main 3.3V supply via an additional LC filter (shown on Fig.10), to minimise the chance of any digital supply noise coupling into the analog portion of the circuit. Both supplies have multiple ceramic bypass capacitors located close to the IC, as well as larger electrolytics in parallel.

Both the FILT+ pin (pin 15) and VQ pin (quiescent voltage, pin 26) have external capacitors connected to filter the internal IC voltages. The audio output appears at pins 23 & 24 (left) and 20 & 19 (right). These are differential outputs and are fed to identical filters. In the article last month, we explained how we tweaked these filter component values to give better rejection of any common mode signal between the differential outputs, as well as a flatter frequency response.

Dual op amp IC4, an LM833, is the active part of these filters and also converts the differential signals to single-ended outputs. The filters remove as much of the high-frequency switching artefacts as possible while leaving audio-frequency signals intact. The outputs are biased to +2.5V so they are AC-coupled using 47µF capacitors and DC biased to 0V. Following this, an RC filter (100Ω/10nF) further reduces the remaining DAC noise.

While the outputs are silent, IC3 drives the AmuteC and BmuteC lines low (pins 25 & 18). These are also held low while IC3 is reset by 10kΩ pull-down resistors. In this condition, current is sunk from the bases of PNP transistors Q3 & Q4 and these then charge up the gates of dual Mosfet pairs Q1a/Q1b and Q2a/Q2b to +5V. Q1 & Q2 are thus on and they short the audio outputs to ground. The 100Ω resistors limit the current from IC3 in this condition to a low level.

By shorting the outputs to ground, any clicks or pops that might be generated from the DAC when powering up or down or switching sampling rates, etc are suppressed. A pair of 47µF ca-



pacitors block the +2.5V DC bias from those same outputs. The 100Ω series resistors isolate any capacitance connected to RCA outputs CON6 & CON7 (eg, cable capacitance) so it won't destabilise the op amp filter circuits.

Back-to-back 18V zeners (ZD1-ZD4) prevent the gate-source voltages of the output Mosfets from exceeding the ±20V rating. This should not happen during normal operation but since the supply rails are ±15V (ie, 30V total), this could possibly happen under some circumstances.

Headphone amplifier

The two audio outputs are also connected to potentiometer VR1 (the headphone amplifier volume control) via another pair of 100Ω resistors. These are intended to prevent any noise that may be picked up in the tracks to VR1 from being fed back to the line outputs. VR1's tracks also form the current path to ensure that the DC at the line outputs is 0V.

The audio signal is attenuated by VR1 (depending on the pot setting) and then fed to the non-inverting inputs of op amps IC6a & IC6b via 100µF capacitors. DC bias is provided by a 4.7kΩ resistor. The capacitor values are high and the resistor values low because, like IC4, IC6 has bipolar input transistors and so has a relatively high input bias current. A low bias resistor minimises DC offset at the output, for reasons we'll explain shortly.

IC4 & IC6 are both LM833 low-noise op amps, still among the best available. The two halves of dual op amp IC6 each drive a current booster circuit in order to deal with headphone impedances as low as 8Ω. The two circuits are identical so we'll just look at the left-channel circuit based on IC6a.

The headphones plug into CON8 and are driven by a standard emitter-follower pair consisting of Q5 (NPN) & Q6 (PNP), each with a 22Ω emitter resistor. These provide some local feedback for Q5 & Q6, limit peak current and dissipation during output short circuits and help to stabilise the quiescent current by providing some negative feedback for the bias circuit.

Q5 & Q6 can handle up to 500mA each but can only safely dissipate 625mW continuously. The 22Ω emitter resistors and 10V zener clamps limit

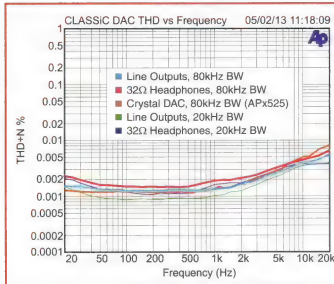


Fig.6: total harmonic distortion plus noise (THD+N) vs frequency. The three main curves shown are for the new DAC from its two outputs (line out and headphones) plus a comparison with the previous Crystal DAC design. Headphone power level is 10mW per channel. The thin lines show how the results with a 20Hz-20kHz bandpass filter, to remove most of the ultrasonic noise.

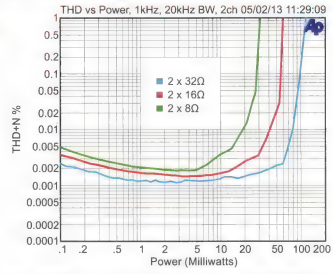


Fig.7: THD+N vs power for the headphone output into three different common load impedances. For headphones with impedances above 32Ω, performance should be similar to (possibly, better than) the 32Ω case up to 50mW. In all cases, we are showing continuous power with both channels driven; for program material (ie, not just a sinewave), more peak power will be available.

CLASSiC DAC Performance Graphs

While the design of the CLASSiC DAC is much more compact and only uses one double-sided PCB compared to our original design back in 2009, its performance is considerably improved. The two main contributing factors to this improvement is the use of the Cirrus Logic CS4398 in place of the Burr-Brown DSD1796 DAC chip and the careful layout of the PCB.

peak current to around (10V - 0.7V) ÷ 22Ω = 423mA but under this condition, the dissipation in Q5/Q6 will be around 423mA x (15V - 10V) = 2W and even more in the emitter resistors. However, the ±15V rails will quickly collapse under this sort of load so this brief period of high dissipation shouldn't cause any damage.

Bias voltage

For good performance, the amplifiers are operated in Class B mode with about 10mA through transistors Q5 & Q6 in the quiescent condition.

We have seen and published circuits in the past which use a pair of diodes or LEDs to set this current but that's a bit hit-and-miss. Instead, in this circuit, we are using a traditional Vbe multiplier consisting of NPN transistor Q7 and trimpot VR2. Q7 is the same type as Q5 and is thermally bonded to it so that their base-emitter voltages track closely. VR2 is adjusted so that the voltage between Q7's collector and emitter is just high enough to give a small standing current through the emitter resistors.

A 10kΩ resistor across VR2 prevents excessive current through Q5 and Q6 should VR2's wiper briefly go open circuit while it is being adjusted. Q7's collector current (and hence some of the drive current for Q5 & Q6) is provided by a pair of 4.7kΩ resistors from each supply rail. A 10µF capacitor across Q7 prevents signal modulation of these currents affecting AC performance.

Op amp IC6a drives Q6's base directly and it also drives Q5's base through a 10µF capacitor (ie, it's AC-coupled). It also drives Q5 via a DC path through VR2 and Q7. With this configuration, in the quiescent condition, IC6a's output is slightly below ground (by around 0.6V). Since the feedback voltage for IC6a comes from the junction of the emitter resistors rather than the op amp output, this is automatically compensated for.

Normally, the headphone amplifier stage operates with no gain. With a full-scale input of 2V RMS from the DAC, it can deliver a maximum of $2V^2 \div 32\Omega = 125mW$ into 32Ω headphones before clipping. Power delivery for lower load impedances is less due to power supply current limiting. The gain is set to one by a jumper link on JP2, shorting out the 3kΩ resistor.

For higher impedance headphones (eg, 600Ω), a higher output voltage is required to get a decent amount of power. In this case, JP2 can be moved to the other position, inserting a 4:1 voltage divider in the feedback path (3kΩ/1kΩ) and thus increasing maximum output to over 8V RMS. However, this also amplifies the DAC and op amp noise, so it should be avoided when driving lower impedances.

The amplifiers are isolated from the headphones with RLC filters, each comprising a 4.7µH inductor in parallel with a 10Ω resistor, with a 100nF capacitor to deck. This is primarily so that any reactance connected to CON8 (again, cable capacitance, or whatever) doesn't destabilise the amplifier circuits.

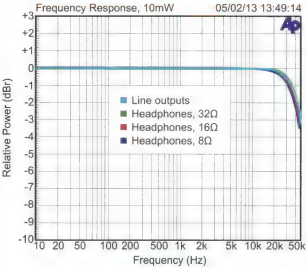


Fig.8: the frequency response is flat from less than 10Hz up to 20kHz. High-end roll-off is greater for lower load impedances such as 8Ω but there's really nothing to write home about here. Deviation is less than 0.1dB over the audible frequency range.

Figs.6-8 show the critical performance figures for the CLASSiC DAC. The distortion and noise from the line outputs is similar to the Crystal DAC (February 2012), which also used the CS4398 IC but the new design is slightly better at the high-frequency end, due to the improved low-pass filter.

By the way, to compare this graph to those published in the February 2012 Crystal DAC article, note that these graphs were produced with an Audio Precision System Two while we used an APx525 for the Crystal DAC, which measures distortion without including noise, ie, THD only, not THD+N.

Headphone output

Since the new DAC also has a headphone output, we have shown a plot of THD+N versus frequency for 10mW into a 32Ω load as well (red trace in Fig.6). This would be a loud listening level. Compared to the blue trace, the distortion is not much higher than that from the line outputs.

On typical program material, the level won't be fixed and most of the time the power level will be well below 10mW. And while most hifi headphones have an impedance of 32Ω or higher, some models have a lower impedance. Fig.7 shows how distortion varies with power at three common headphone impedances.

In each case, THD+N rises as the power level drops below about 5mW as the residual noise begins to dominate the result. In fact though, the distortion continues to drop with reducing power and will actually be below .001% at 0.2mW rather than the .002% figure with noise included, as shown in Fig.7.

At impedances below 32Ω, distortion is higher and power delivery is lower due to the increased current required to drive the load. Still, the results are quite reasonable at moderate power levels with a THD+N below 0.005% for impedances of 8Ω and above up to 15mW.

The signal-to-noise ratio is better than 100dB for the headphone outputs driving a 32Ω load (relative to 50mW) and 110dB for the line outputs. And as you can see from Fig.8, the frequency response is very flat, down by just 0.1dB at 20kHz.

If you want even lower distortion and more power, you could build the Hifi Stereo Headphone Amplifier (September-October 2011) and plug it into the line outputs of the DAC.

This type of filter gives a reasonably flat frequency response with a narrow range of load impedances. Since we don't know exactly what impedance headphones will be used, we've designed the filter for a middle-of-the road value (around 16Ω). In practice, this gives a flat response with a wide range of headphone impedances (see Fig.8).

For minimal distortion, the inductor in the output filter is an air-core type. To save space on the PCB and reduce cost, we have simply wound coils of enamelled copper wire around the two 10Ω resistors. These resistors don't dissipate much but we have used 1W types so that they are large enough to wind the coils on.

De-thumping

As with the line outputs, there is a pair of dual Mosfets connected so as to short the output to ground when there is no audio signal. In fact, these Mosfets gates are simply hooked up in parallel with those of Q1 and Q2 and operate simultaneously.

Without this, there could be a loud thump or crack if the unit is powered up or down with the headphones connected. This is mostly due to the various capacitors taking time to charge up to their normal operating voltages but also depends on which of the supply rails comes up first.

By shorting the outputs to ground before switching on the ±15V rails and for a short time afterwards, this signal is shunted to ground and so very little of it passes through the headphones. But to minimise noise, we need the headphone amplifier output to be very close to ground when there is no input (ie, a very low offset voltage). Otherwise there will be a click when Q15/Q16 switch on and off.

The offset is normally only a few millivolts but that can still be audible with a sensitive pair of headphones. So that is why we are using low-value input bias resistors for IC6.

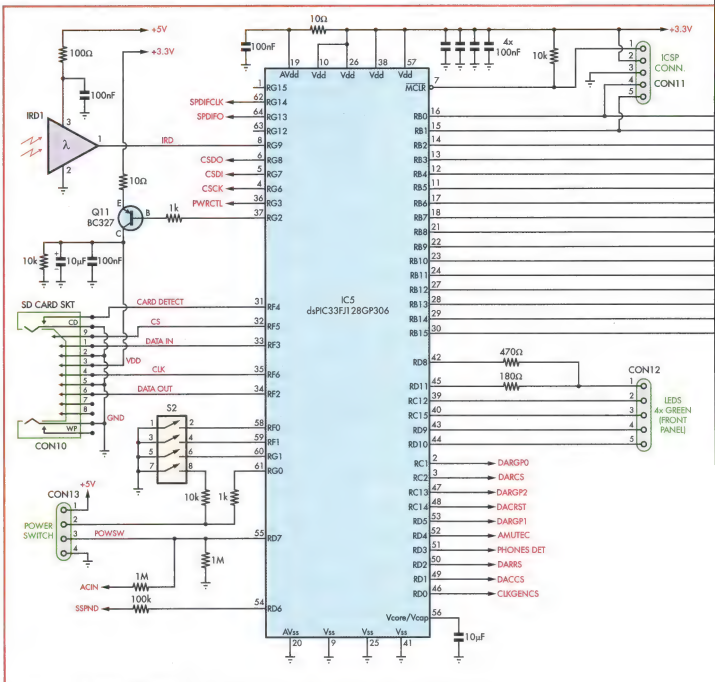
Note that while transistors Q15 & Q16 are on and various capacitors are charging, the amplifier will be trying very hard to pull the output away from ground but it won't be able to. In this case, the short-circuit protection will be active until the circuit settles down. There will also likely be a fair bit of ripple on the ±15V rails during this time due to the relatively low current capability of the power supply (which we'll explain later).

Proper regulation has resumed by the time Q15 & Q16 turn off.

Control circuit

The micro has to set up the CS8416 digital audio receiver (IC1) and the CS4398 DAC (IC3) before they will operate correctly. It also communicates with them during operation, to determine the status (such as sampling rate) and change settings (eg, input switching).

This is all done by microcontroller IC5, as shown in Fig.9. The SPI bus for IC1 & IC3 connects to its pins 3, 4, 5, 6 & 49 and thence to IC5's internal SPI transceiver. Pins 48 & 50 control the reset lines for the two aforementioned



CLASSIC DAC CONTROL, FRONT PANEL & CLOCK GENERATOR SECTIONS

Fig.9: the control circuit uses microcontroller IC5 to run the show. It is a 16-bit digital signal controller and can read WAV files up to 96kHz 24-bit from an SD card in socket CON10 and output an S/PDIF audio stream from pin 64 to IC1. LEDs1-8 show the state of the eight inputs (including the SD card) while LEDs9-12 indicate the sampling rate. Clock generator IC7 is used to provide the sampling clock when playing back WAV files.

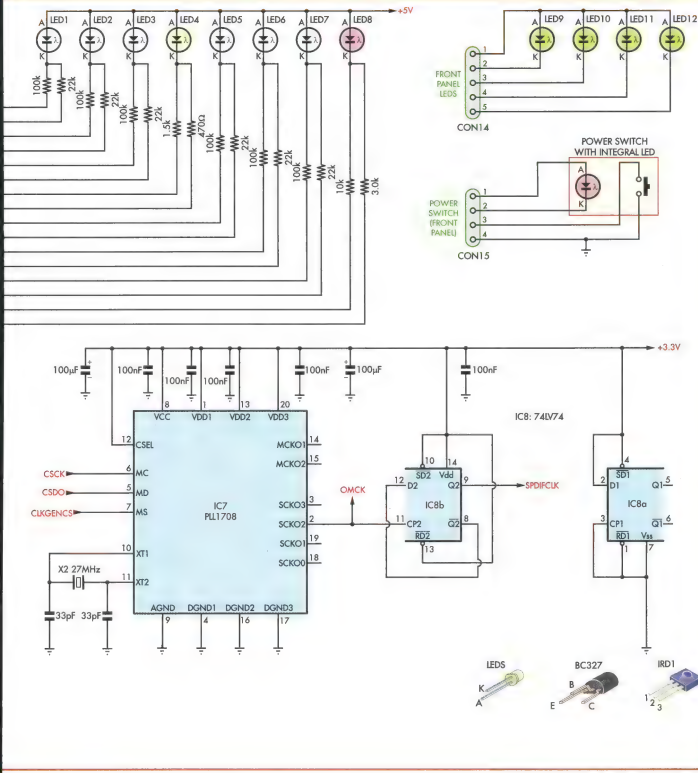
ICs while pins 2, 47 & 53 connect to the GPO pins on the digital audio receiver (IC1, Fig.4) for the functions explained previously.

The micro also monitors the AmuteC output of the DAC at pin 52 so that it can determine when the output is silent.

IC7 is a clock generator which produces the sampling rate clock when playing back WAV files from the SD card. It shares the same SPI bus for control, with a third chip select line (CLKGENCS) driven from pin 46 of IC5. IC5 uses this bus to turn the clock output on and off and set its frequency.

IC7 uses a 27MHz crystal and internal PLLs to generate the OMCK output for IC1. This clock is also fed to the pin 11 input of flipflop IC8b which acts as a clock divider. Each time CP2 goes high, the output at Q2 (pin 9) inverts because the inverting output Q2-bar (pin 8) is connected to the data input D2 (pin 12).

The result is that the SPDIFCLK output from pin 9 is at half the rate of

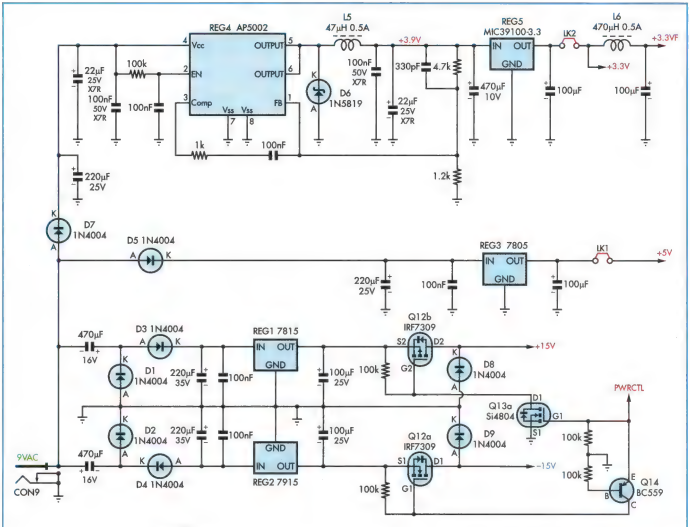


OMCK and this goes to pin 62 of IC5 which is the Data Converter Interface (DCI) clock input. This controls the timing of the DCI serial output from pin 64 of IC5, which goes to input RXP7 on IC1 via a 10nF AC-coupling capacitor.

When the micro wants to transmit audio to the DAC, it sets up IC7 to provide an appropriate clock and switches IC1 to input channel 7. It can then use a software routine to generate an S/PDIF stream which is output via the DCI peripheral to the receiver, to be decoded and sent on to the DAC.

To do this, it must read the WAV data off the SD card and this is done with a second SPI interface. Pins 32 (card select), 33 (data in), 34 (data out) & 35 (clock) simply connect directly to the SD card socket while pin 31 is used to sense whether a card is inserted, using a switch internal to the socket and a weak pull-up current internal to IC5.

Power to the SD card socket is switched using PNP transistor Q11 which is controlled by pin 37. We



SC 03013 CLASSIC DAC POWER SUPPLY SECTION

Fig.10: power comes from a 9VAC plugpack. A charge pump voltage doubler feeds regulators REG1 & REG2 to provide ±15V rails to run the op amps and headphone amplifiers. These supplies are switched off using Q12 & Q13 when the unit is in standby (ie, when PWRCTL is low). Some components (eg, the DAC) require +5V and this is provided by a half-wave rectifier D5 and regulator REG3. The digital chips run from 3.3V and this is provided by switchmode stepdown regulator REG4 and linear post-regulator REG5.

wait until the card is fully inserted to power it up and a 10Ω series resistor limits the in-rush current while a pair of capacitors provide a low-impedance supply for the card. A parallel resistor prevents these from charging via Q11's leakage current when it is off.

User interface

The DAC's state is displayed using 13 front-panel LEDs. Eight show the input status and they are connected to pins RB0-RB15 of IC5, each with two different value current-limiting resistors so that they can be driven at four brightness levels without the need for PWM. In practice, three levels are used: off (both outputs high impedance), dim (one output low) and bright (both outputs low). LED1 shows the status of input 1, etc.

LEDs9-12 indicate the current sampling rate. A cable connects CON14 on the front panel to CON12 on the main board. These LEDs share a pair of current-limiting resistors at the common anode connection point as normally only one is lit at any time. Their brightness is based on whether audio is present (as opposed to merely a digital signal).

The final LED is integral to the power button and this too is connected via a header and short cable, from CON13 on the main PCB to CON15 on the rear of the front panel. Its LED glows dimly in standby mode and brightly when the unit is powered on. But only one resistor is driven by the micro; the other is switched by part of DIP switch S2. Thus the LED can be switched off in standby if desired, using S2.

The unit is controlled by the aforementioned front panel power switch (via CON13/CON15) and also by infrared remote control, using infrared receiver IRD1. As well as on/off control, the front panel pushbutton can be used to cycle through the input channels. Thus if you simply want to change inputs, you don't have to go looking for the remote control.

All other functions are performed using the remote. The Philips RC5 protocol is used as this is easy to decode and supported by virtually all universal remote controls. The output of IRD1 is a square wave and when its level changes, this triggers an interrupt handler routine in the software which then decodes the pulses. IRD1 runs off the 5V rail and it has an RC filter to ensure there is no noise on this line, as infrared receivers can be quite sensitive to noise.

Microcontroller IC5 runs off the 3.3V rail and has a number of ceramic bypass capacitors, plus an RC filter for its analog supply. CON11 is an optional 5-pin in-circuit programming socket which allows IC5 to be re-flashed (IC5 is an SMD, so you would otherwise need a special socket to program it).

S2's remaining three switch banks are used to configure some of the basic functions of IC5, such as whether it will automatically scan for an active input. IC5 has no internal pull-ups to enable on the connected pins so at start-up it drives pins RF0, RF1 & RG1 high for a very brief period (less than 1µs) and senses the voltage on each.

If the associated switch is on, the connected pin voltage will remain close to ground despite being driven "high", as the output transistor's internal impedance limits the current it can deliver. Because these "shorts" are so brief, they don't risk damage to the output transistors.

Pin 36 of IC5 (RG5) is the power control line which switches the ±15V rails on and off, both to conserve power during standby mode and to avoid thumps and clicks from the headphone output at power up/down, as explained earlier. It is active-high.

Power supply

Fig.10 shows the DAC's power supply. It derives four regulated rails from a 9VAC plugpack and is designed to be efficient enough to not require any heatsinks.

The 5V supply is the simplest. Diode D5 rectifies the incoming AC and charges a 220µF capacitor to 12-15V, depending on the exact plugpack voltage. This is then linearly regulated to 5V by REG3. The current drawn from the 5V rail is modest, so REG3 dissipates relatively little power.

Much more current is drawn from the 3.3V rail; up to about 200mA, including 100mA for microcontroller IC5. As such, we're using a switch-mode regulator with a linear post-regulator to keep the output clean. The AC is rectified by diode D7 and filtered with another 220µF capacitor, then REG4 (AP5002) steps the 12-15V down to 3.9V.

It is a "buck" regulator so it does this by rapidly switching its output on and off, at 500kHz, and then filtering the resulting PWM waveform with an LC filter consisting of L5 and a 22µF SMD ceramic capacitor. This part of the circuit is very similar to that shown in the AP5002 data sheet.

The 3.9V is then regulated to 3.3V using low-dropout linear regulator REG5. Another LC filter consisting of L6 (470µH) and a 100µF capacitor removes even more of the switching noise for the supply to the DAC as this is the part which is most sensitive to noise on the 3.3V rail.

LK1 & LK2 are pairs of closely-spaced pads on the PCB which exist to allow constructors to check that the power supply is working before connecting it up to the rest of the circuit (ie, by soldering the pads together).

Higher voltage rails

The ±15V rails for the op amps and headphone amplifier are generated from the low-voltage AC supply using a charge pump. Consider the positive half of this pump. When the inner conductor of CON9 has a negative voltage relative to its barrel, current flows through diode D1 from ground and into the connected 470µF capacitor, charging it up to around 12V DC (ie, 9VAC x √2).

When the AC voltage then goes positive, the positive side of this capacitor goes to nearly 24V (the AC peak plus the capacitor voltage) and thus diode D3 becomes forward-biased, charging the 220µF 35V capacitor to a similar level. This voltage then powers REG1, a +15V linear regulator, to provide a steady +15V rail for the op amps. The -15V part of the circuit is symmetrical and works in the same manner.

Since input current for each of the ±15V supplies is drawn on both the positive and negative phases of the input AC waveform, the current drawn from the plugpack is roughly twice that drawn from the ±15V rails.

Due to the impedance of the capacitors in this charge pump (ie, they partially discharge over the course of each AC cycle), current available on these rails is limited but is quite sufficient for our purposes.

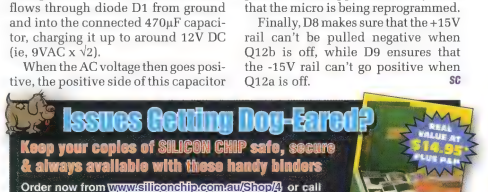
The +15V rail is switched by Q12b, half of a dual P/N-channel Mosfet. This is the P-channel device so it turns on when its gate is pulled low by Q13a, an N-channel Mosfet. When PWRCTL goes high, Q13a switches on and this in turn pulls Q12b's gate to ground, enabling the +15V rail.

At the same time, with PWRCTL high, Q14 turns on. This pulls up the gate of N-channel Mosfet Q12a, switching it on and enabling the -15V rail. A pair of 100kΩ resistors keeps both switches off if PWRCTL is high-impedance, which will be the case when power is first applied and any time that the micro is being reprogrammed.

Finally, D8 makes sure that the +15V rail can't be pulled negative when Q12b is off, while D9 ensures that the -15V rail can't go positive when Q12a is off. SC

Pt.3 Next Month

Next month, we will describe how to build the CLASSiC DAC and also explain how to test and configure it. If we have room, we'll also give a brief explanation of how some of the more interesting features in the software operate.



Measure sound and vibration way below human hearing

by Allan Linton-Smith and Ross Tester

INFRASOUND DETECTOR

Photo: Harvey McDaniel Wikipedia

Are wind turbines making you sick? Is building vibration making you nauseous? Or do you just want to measure infrasound in your environment? You don't need to spend thousands of dollars to do it properly; just build our low-cost but accurate Infrasound Detector.

There's been a lot of press lately about infrasound, particularly as it applies to wind turbines. But until now, you've needed tens of thousands of dollars worth of test equipment to detect and measure it.

Our Infrasound Detector can be built for less than a hundred dollars yet will give very accurate results. You can either read the sound pressure directly or store and analyse readings on your computer!

So what exactly is infrasound?

It can defined as sound below the range of normal human hearing. That's generally reckoned to be below about 20Hz.

Below that, you can perhaps sense or even "feel" sound but you can't actually hear it.

In practice, infrasound involves frequencies from about 20Hz to 0.5Hz but some natural phenomena can cause infrasound down to the millihertz (.0001Hz!) region.

When people complain about ill-effects from infrasound (and there are legions of those reports), many acoustic consultants have taken the attitude that "if you can't hear it, it can't be doing you harm".

We disagree – and the publisher of this magazine even wrote an editorial on the subject back in February 2010.

Reported human reaction to infrasound from wind turbines is varied but some of the reports associate infrasound with a general feeling of malaise, nausea, vertigo, blurred vision, memory problems, tinnitus, anxiety, uneasiness, extreme sorrow, nervous feelings of revulsion or fear, chills down the spine and feelings of pressure on the chest.

Others have reported headaches and migraines, major sleep disorders and even self-harm tendencies.

Some researchers have even given it a label: wind turbine syndrome.

Wind turbines are one example but you'll also find infrasound caused by traffic noise, heavy surf, engines/motors (especially things like compressors), building vibrations being excited by wind, machinery and so on.

Large animals such as whales, crocodiles, alligators, elephants and emus communicate with infrasound so if you want to record amorous crocodiles, our Infrasound Detector is a good way to go about it (from a safe location!).

Other source of infrasonics are heavy artillery, the calving of icebergs from glaciers and earthquakes.

In fact, there is a theory that the buildup of stresses with the earth's crust before a major earthquake causes infrasound – which could explain why birds and some other animals appear to have some warning of an imminent quake.

Want another example? The very act of opening or closing a door produces infrasound waves. But that is transitory – you don't normally stand there for hours opening and closing doors!

Whatever the infrasonic phenomenon you want to investigate, our Infrasound Detector is an effective and low-cost way to do it and it compares more than favourably with commercially available equipment.

While it's economic, it's also ac-

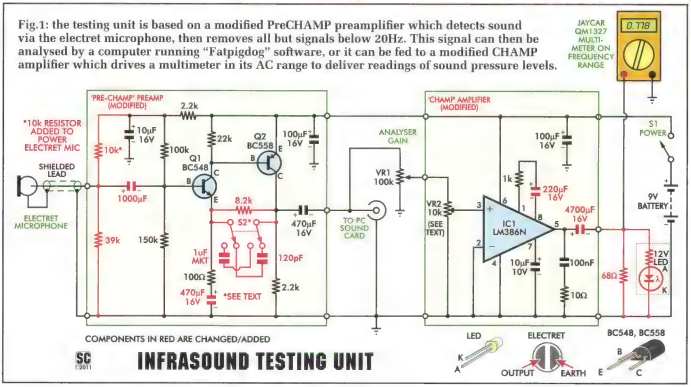


Fig.1: the testing unit is based on a modified PreCHAMP preamplifier which detects sound via the electret microphone, then removes all but signals below 20Hz. This signal can then be analysed by a computer running "Fatpigdog" software, or it can be fed to a modified CHAMP amplifier which drives a multimeter in its AC range to deliver readings of sound pressure levels.

Our Infrasound Detector is built into a small diecast box, with an old microphone shield attached to the front. Inside this shield is a low-cost electret mic insert. The terminals at left are the output to a frequency counter (or in our case, a budget multimeter) while a socket is provided on the right side for output to a PC sound card. Suitable analysis software is quite cheap.

Specifications

Microphone frequency response G-weighted: ±2.0dB corrected (0.5Hz-26Hz)
Microphone frequency response C-weighted: ±2.0dB (10Hz-20kHz)
Microphone intermodulation distortion: 0.8% @ 100dB SPL
Preamplifier frequency response: ±0.2dB (0.5Hz-20kHz)
Power amplifier frequency response: ±0.2dB (0.5Hz-20kHz)
Power amplifier output (before clipping): 200mW into 8Ω
Frequency response of virtual instrument: ±0.4dB (0.5Hz-20kHz)
Overall measuring accuracy –
Without calibration table: ±15dB (20Hz-20kHz)
Using calibration table: ±1.0dB (2Hz-20kHz)
THD+N preamplifier: 0.102% at 1kHz (5Hz-22kHz)
THD+N power amplifier: 0.40% at 1kHz (5Hz-22kHz); 250mW
Preamp input maximum: 50mV
Preamp input minimum: 1.0mV
Power amp input maximum: 500mV
Power amp input minimum: 30mV
Preamp phase distortion: ±6.35° (below 200Hz)
Preamp intermodulation distortion: 0.095% (88mV output 70Hz/7kHz)
Preamp S/N ratio: -107dBV (10Hz-80kHz ref 630Hz 25mV)

curate and reliable – we believe it can be just as accurate and reliable as commercial gear.

In fact, while our unit should cost well under $100 to build and is easy to put together, it took hundreds of hours to develop and test. That is because infrasound sweeps can take hours to settle, measure and average – and some very specialised and expensive equipment was required to design and test it.

If you wanted to buy that commercial equipment yourself, you'd have little change from $30,000!

We also had to develop a method for testing and calibrating high levels of infrasound without upsetting the neighbours!

How it works

The output from a wide-range electret microphone is fed to a very-low-frequency bandpass filter. The infrasound signal is amplified and fed to a "virtual" spectrum analyser which then plots the amplitude of the infrasound signal on the vertical (Y) scale versus frequency on the horizontal (x) scale using a principal known as Fast Fourier Transform (FFT).

A computer can then be used to analyse the signal and/or a direct frequency readout can be obtained if used in the field.

Good grief: The CHAMP is back!

After constructing many circuits which offered good theoretical performance we discovered that the good old PreCHAMP preamplifier, combined with the equally elderly CHAMP audio amplifier, could be easily modified to do the job admirably.

Yes, we know, we said only two months ago that our new CHAMPION amplifier would kill off the PreCHAMP and CHAMP but there's a good reason for resurrecting it here: low quiescent current.

The PreCHAMP and CHAMP draw only about 4mA each on idle, so prolonged operation (which you'll need for field checks) is quite practical using only a 9V battery.

By comparison, the CHAMPION draws up to 60mA so your 9V battery wouldn't last long at all!

If you built the CHAMPION project (based on the Panasonic AN7511), you could use it for infrasound with only a few modifications but you'll probably need to use it with an external supply.

As used here, the modified PreCHAMP now has much improved frequency response; within +/-0.2dB from 2Hz – 20kHz. The modified CHAMP also gives a flat frequency response at around 0.25-0.5W – so you can feed any oscilloscope or low frequency counter.

Optional CHAMP

The CHAMP is optional – it has been included so that you can take quick measurements in the field.

The PreCHAMP is set up as a bandpass filter and high gain amplifier which is approximately G-weighted, ie, its centre frequency is around 10Hz with -3dB points at 500mHz (0.5Hz) and 26Hz.

A selector switch is provided for switching to "C" weighting (ie, flat response) so that the unit can easily be calibrated at 1kHz.

The infrasound signal from the PreCHAMP is fed to the CHAMP amplifier which has been modified to give a flat frequency response from 0.5Hz to 20kHz and is set at high gain so that the signal output to a frequency counter is over 130mV at 1Hz.

Frequency counter?

Whoops! Haven't got one of those? That little problem is solved very cheaply with a multimeter – specifically the Jaycar QM1327 auto-ranging multimeter, which can read read down to 0.1Hz and sells for only $34.95.

While its specs state it needs a minimum of 3V RMS AC before it will show a frequency reading, we found that it far exceeded its specification and 130mV was sufficient. Few frequency counters go below 10Hz so the Jaycar meter represents good value in this application.

If you use the CHAMP together with the Jaycar multimeter, then you will be able to determine SPL (the sound pressure level in dB) by switching the DMM to AC volts. This will give an approximate SPL in dB (decibels) as described.

For signals below 0.5Hz this approach will not be accurate but this will be more than sufficient for the majority of applications.

Fatpigdog again!

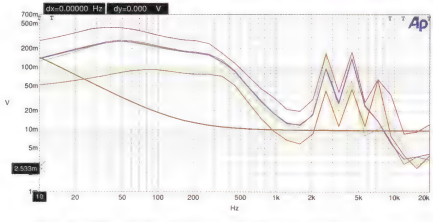
The direct readout is very handy in the field but if you want to do some real analysis, you'll need a computer and suitable software.

Readers may remember "fatpigdog" from our feature article on measuring

Electret Microphones

The electret microphone is pretty inefficient at frequencies below 25Hz, hence the very high amplification.

There are lots of electret microphone inserts available but we are specifying a particular Jaycar model (Cat AM-4011) because we found it to be a very good match for this project. However, you can see from the graphs below that even these specific Jaycar mics are not all the same – some are more sensitive than others due to manufacturing variations – so you may need to buy a few to experiment.

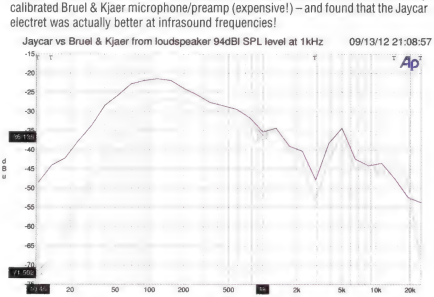


Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment	Cursor1	Cursor2
2	1	Green	Solid	7	Anlr.Level A	Left		124.2 mV	124.2 mV
3	1	Yellow	Solid	7	Anlr.Level A	Left		55.61 mV	55.61 mV
4	1	Red	Solid	7	Anlr.Level A	Left		51.84 mV	51.84 mV
5	1	Magenta	Solid	7	Anlr.Level A	Left		140.1 mV	140.1 mV
6	1	Blue	Solid	7	Anlr.Level A	Left		136.9 mV	136.9 mV
8	1	Green	Solid	7	Anlr.Level A	Left		146.1 mV	146.1 mV
9	1	Red	Solid	7	Anlr.Level A	Left		141.8 mV	141.8 mV
10	1	Red	Solid	7	Anlr.Level A	Left		284.9 mV	284.9 mV

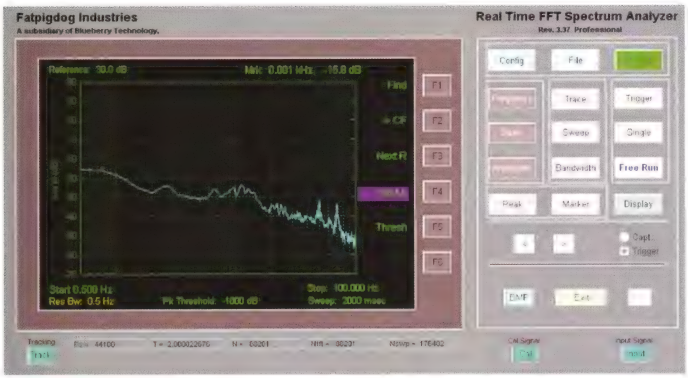
Because they have flying pigtails changing them is a pretty easy soldering task.

Each electret will need to be calibrated as described below in the "Calibration" section to enable you to assess sound pressure level (SPL).

By the way, we averaged the frequency response of several of the Jaycar electret microphones combined with the Pre-CHAMP and compared them with an accurately calibrated Bruel & Kjaer microphone/preamp (expensive!) – and found that the Jaycar electret was actually better at infrasound frequencies!



Sweep	Trace	Color	Line Style	Thick	Data	Axis	Comment	Cursor1	Cursor2
1	1	Cyan	Solid	10	Anlr.Level B	Left	Bruel&Kjaer	*-36.135 dBu	*-71.502 dBu
2	1	Magenta	Solid	10	Anlr.Level A	Left	Jaycar electret	-35.306 dBu	-48.482 dBu



We used this sweep to show that 1Hz was easily detectable with a resolution of 0.5Hz. By correction, the sound source is 100dB. You need to be patient because the analyser sometimes sets the sweep time to 10 seconds automatically and you have to wait before you can make adjustments.

Loudspeaker Frequency Response in the December 2011 issue.

We're using this software again but it has since been updated considerably (the latest version is 4.04) and has more usable functions than the original version. You can purchase and download the software for around $30 from **www.fatpigdog.com**.

On their website, you will also find various dedicated bench top spectrum analysers for sale but the virtual instrument is about 99.9% cheaper!

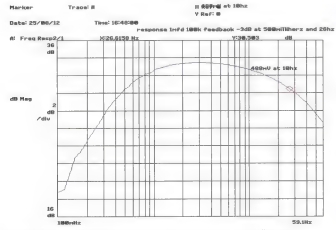
Fatpigdog is fun to use, easy to manage and includes all sorts of extras such as a waterfall display, spectrum analysis to 22kHz, BMP capture and much more.

The PreCHAMP output is simply fed to the sound card input of your computer.

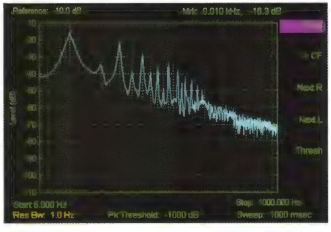
You could feed the spectrum analyser from the 'CHAMP' output but we don't recommend this because your computer soundcard is usually set up for microphone-level inputs (ie, millivolts not volts). Any large voltages will usually result in clipping and consequently the spectrum analyser will show multiple peaks from the odd harmonics.

The Jaycar multimeter is an option if you wish to have a hand held detector for quick infrasound detection without having to set up a computer and adjust the software.

It is fed from the Pre-CHAMP output via the 10k preset pot. You can set the maximum output from the



Using the Agilent 35670A, the sweep gives the lower response for the G-weighted PreCHAMP down to 0.1 Hz... that's 1 cycle every 10 seconds! -3dB points are 0.5Hz and 26Hz. Mains hum is not a problem at these frequencies!



Fatpigdog spectrum of a 15-inch speaker fed with 200W. The resolution is set at 1Hz and the sweep time is one second. You could actually feel the sound – and it was not nice!

The Jaycar QM1327 Multimeter works fine as a frequency meter and also an AC voltmeter. It's simply held in place on the back of the Infrasound Detector with self-adhesive hook'n'loop tape (usually sold under the "Velcro" brand).

"CHAMP" by setting the preset fully anti-clockwise.

The only other modification is the addition of a 68Ω "dummy load" resistor which prevents the output capacitor from building up a DC charge, which would otherwise result in false readings. You *could* attach a loudspeaker instead but you won't hear much below 25Hz (and it will drain the battery more quickly).

By changing the parameters on the analyser – such as sweep time, start and stop frequencies and resolution bandwidth, you can save and print your spectra for further analysis.

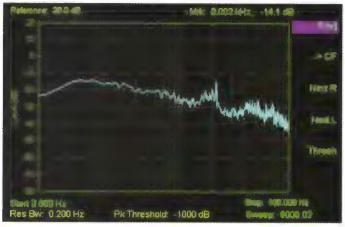
Furthermore, by setting the spectrum analyser to "max hold" you will be able to observe any infrasound which occurs during an extended period of time.

Using the virtual spectrum analyser requires some practice and patience (just like a real benchtop spectrum analyser) but if you experiment, you will learn to master it all fairly quickly. We'll have much more to say on this later.

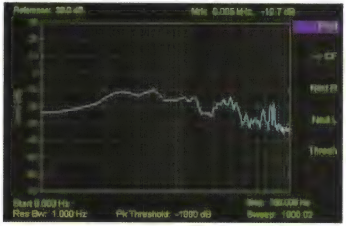
Construction

The "hardware" is built into an aluminium diecast box (to minimise noise) measuring 119 x 93.5 x 34mm (eg, Jaycar HB5067). Inside this are the PCBs for the modified PreCHAMP (and CHAMP if you wish to use it) and a 9V battery in suitable holder.

Layout is not particularly critical but given the very high amplification of the PreCHAMP/CHAMP combina-



This spectrum shows the maximum sound level for suburban Pacific Highway traffic. The microphone is a good 5-10 metres away from vehicles and there is significant noise at 2Hz! Note also the peak at around 20Hz – probably from engines.



You can set up the detector and leave it running for up to an hour. We caught a distant thunder clap at 5Hz and a calculated 84dB. The resolution was set at 1.0Hz and the sweep time was one second. The maximum hold function runs continuously and updates every second.

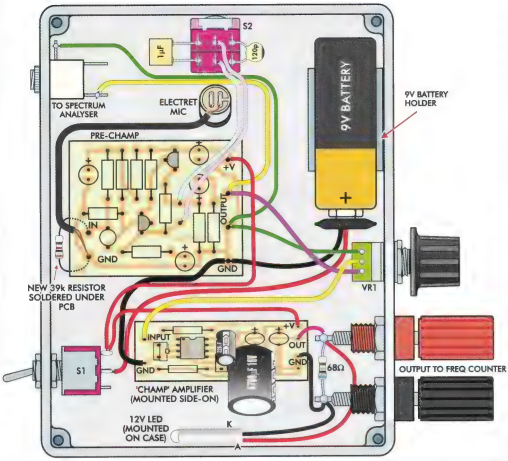


Fig.2 (above): component layout is not critical but this diagram should give you a guide. Both the PreCHAMP and CHAMP PCBs are held in place with double-sided foam pads. The photo at right shows the same internal view, together with the T-nut tripod adaptor we fitted to the end of the diecast case.

tion (about 4000 times), outputs should be kept relatively clear of inputs, as is normal practice for an amplifier.

Start by constructing the Pre-CHAMP pre-amplifier as per the instructions given with a kit (or refer to SILICON CHIP July 1994).

See Figs.1&2 for the modifications required – you will only need to change the values of three capacitors and these will easily fit on the PCB.

The 39kΩ resistor should be soldered to the underside of the board input or across the input pins.

To the two holes on the board marked "1n5" solder two leads and connect these leads to the two central pins of DPDT switch S2.Then solder the 1uF capacitor to one side and the 120pf capacitor to the other (see photo).

Then run leads to CON3 and VR2 as shown in the wiring diagram.

We could have used just a simple SPST switch to switch the larger capacitor in and out of circuit but the arrangement shown (using a DPDT switch) allows easy mounting of the two external capacitors: they are simply wired across the outside terminals and the wires back to the PCB are wired to the centre terminals.

Assuming you want to include the "CHAMP" power amplifier, to provide sufficient voltage to the Jaycar Frequency meter (multimeter), construct it as per the kit instructions (or refer to SILICON CHIP February 1994).

The modifications we have made to give a flatter frequency response involve changing two capacitors. You will find that the 4,700μF capacitor is large but fits neatly on the PCB. However, it is a little too tall and the finished amplifier will have to be put on its side so it can easily fit in the diecast box.

Now you can drill and mount all the hardware on the diecast box using the picture as a template and solder all the wires up according to the diagram.

Fitting a tripod adaptor

To enable easy use in the field, we wanted to be able to attach the unit to a photographic tripod. So we fitted

As it has a 1/4-inch Whitworth internal thread (same as most tripods) we used one of these furniture T-nuts from a hardware store, flattened out the points, and drilled the box to suit. Then we glued it in place with some 2-part epoxy.

our box with a 1/4-inch threaded bush (Whitworth thread; standard on most tripods/cameras/etc).

In fact, we used a "T-nut" fitting intended for furniture and shelf hardware (pictured) which has an internal 1/4-inch Whitworth thread. It had four punched points intended to help it grip timber – we simply flattened these out with a hammer, then glued it in place with epoxy inside and out, making sure no epoxy got inside the thread.

T-Nuts are available from most hardware stores and they are really cheap! However, you need to ensure you do get 1/4 Whitworth – it appears that 5/16 and 3/8 are much more common.

If you must use 3/8-inch, 3/8 to 1/4-inch adaptors are available from better photographic stores.

Finishing off

It will be easier to solder the wires to the boards first, then solder the wires to all the switches and sockets before mounting them inside the box.

Because the circuit boards are tiny and sometimes have no provision for normal screw mounts, you will have to use some good quality, thick double sided foam pads. Cut it to cover the bottom of the "pre-CHAMP" board then press it firmly in place, allowing plenty of room for everything to clear.

Then fit the "CHAMP" amplifier by putting double sided tape to the side 4,700µF capacitor and the side of the board and then pressing it all into place as shown.

Check again to see if any wires have come loose then mount the battery in its holder and switch on. The current drain should be about 8mA or so. If all is OK, put the lid on and plug in your computer, set up the software and start testing.

The microphone

For the microphone assembly, drill a hole large enough for the electret in the base of the box, solder a short length of shielded cable to the microphone with the shielding to earth (the side connected to the outer case of the electret) and the other end to the the input terminals of the PreCHAMP.

We are looking at frequencies below 30Hz on the G-weighting setting so hum should not be a problem until you switch to C-weighting

We cut the top off an old dynamic mic and mounted it on the box, then attached the electret to the side with double sided tape as shown.

We maintained the original mic thread to allow us to attach a wind shield and also to calibrate our setup and to make quick changes to test various microphones without having to unscrew the box all the time.

But this is not critical and you can just stick the electret to the inside of the box with double-sided tape or even solder it directly to the input pins and just have an appropriate hole in the diecast box.

Whatever you do, you should be able to access the electret to enable quick changes because there is significant variation between electrets as the graphs will show and having it mounted on shielded cable makes it easier to solder and unsolder.

Here's how we mounted the electret microphone, using an old dynamic mic windshield as the base. The insert is held in place with an adhesive foam tab.

Checking it out

Once everything is done connect the output from the pre-CHAMP to your computer Mic input making sure your

Parts List – Infrasonic Detector

1 PreCHAMP Kit
1 CHAMP Kit [optional - see text]
1 Diecast box (eg, Jaycar HB5067)
1 frequency-reading multimeter (eg, Jaycar QM1327) [optional - see text]
1 SPST miniature toggle switch (S1)
1 DPDT minature toggle switch (S2)
1 3.5mm mono socket, panel-mounting
1 banana socket - red
1 banana socket - black
1 short red wire fitted with banana plugs each end
1 short black wire fitted with banana plugs each end
1 electret microphone insert (eg Jaycar AM-4011) [see text]
1 microphone
1 1/4-in Whitworth T-nut for tripod mount [see text]
1 9V battery
1 U-shaped 9V battery holder
1 3.5mm to 3.5mm shielded audio cable (to connect to sound card)
Short lengths hookup wire and shielded audio cable
Double-sided adhesive foam pads
Self-adhesive hook & loop tape, etc
Epoxy glue (for tripod adaptor)
1 Fatpigdog Virtual Analyzer program (download from www.fatpigdog.com [approx. $30]).

Semiconductors
1 LED, panel mounting 12V type

Capacitors
1 4700µF 16V electrolytic
1 1000µF 25V electroyltic
2 470µF 16V electrolytic
1 1µF MKT
1 120pF ceramic

Resistors
1 39kΩ 1 8.2kΩ 1 68Ω
1 100kΩ (or 50kΩ) log pot
1 knob to suit pot

Frequency (Hz)	ADD dB to measurement
0.5	41
1	29
2	17
3	11
4	8
5	5
6	4
7	3
8	2
9	1
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0.5
21	1
22	1
23	1.5
24	1.8
25	2.5
26	3
27	3.2
28	3.3
29	3.4
30	3.5

Table 1: Correction table for a Jaycar AM-4011 electret mic insert.

sound card mixer is set flat; ie, no bass or treble boost.

Check to see if the microphone is working by switching to C-weighting and then talking or whistling. Measure the output with a DMM set on AC or plug the output into an amplifier or oscilloscope.

Alternatively, you might like to plug the output of the Pre-CHAMP into the mic socket of your computer soundcard and view your "whistle" on the spectrum analyzer. Your whistle should give you a peak at around 1-2kHz, plus harmonics at 2 and 3kHz.

Once all your checks are done switch it to G-weighting and observe the LED (assuming you have added the CHAMP) It should flash in time with the signal and you can open and shut a door to test it (a car door opening is approx 0.5-2Hz). If all goes well you will finally be ready to fine tune it all and try some infrasound testing.

Plug in the Jaycar multimeter, switch it to the Hz range and read off the frequency. On C-weighting you will probably see something in kHz but on the G-weighting setting you should see frequencies below 20Hz.

The frequencies will probably jump around a bit and you can vary the gain control to stabilise the readings.

In the SILICON CHIP office, we saw 8Hz coming up consistently on the counter and also on the spectrum analyser.

It disappeared when we switched off our air conditioner but it was a hot day so we put up with the 8Hz (although it was less than 75dB [SPL]).

Calibration

As we mentioned before, calibration is only really needed if you want to establish sound pressure level .

Frequency calibration is already inbuilt in the software and multimeter and is not required for our purposes.

It is fairly straightforward but it will help if you already have a sound level meter (like the Jaycar QM1591) and an audio oscillator but if you don't have these items and you don't calibrate, you will still get a pretty good idea from the relative dB levels indicated in the spectrum analyser.

For example our leaf blower is rated at SPL 70dB at one metre. We set the detector to C-weighting and found that the fatpigdog analyser indicated -15dB at 35Hz at 1 metre, so switching to G-weighting will mean that any infrasound frequency BELOW 26Hz will also be 70dB, if you see -15dB on the analyser.

Sure, it's a rough measurement but there are many devices which have a dB rating on their label such as mowers, snippers, saws etc and you can check these out.

For a more accurate calibration, feed a tone (say 1kHz) through an amplifier and loudspeaker and check your C-weighted result against your C- weighted sound level meter. Try various levels, incrementing them by 5dB.

Most sound level meters have absolutely no response below 35Hz so there is no point checking the G-weighted setting.

If you don't use the fatpigdog software, don't worry because you can switch the Jaycar multimeter to "AC volts", making sure the gain control is fully advanced and just take note of the reading at various sound pressure levels. Our setup showed approx 0.9v AC at 94dB.

For frequencies below 7Hz the accuracy falls off somewhat but if you are looking at 0.5Hz, just switch it to DC volts and watch the rise and fall!

Other unique applications – vibration anaysis

This instrument is very useful in checking out vibration problems as we found with our 8Hz air conditioning. Sometimes these problems go undetected for years and some have claimed that they may be responsible for nausea, headaches, sleep problems or just a general sense of unpleasantness.

Additionally, traditional methods of sound level monitoring have only focussed on the audible spectrum and have not even considered infrasound effects on the human (or animal) body and the access to infrasound measuring devices has been both difficult and expensive.

Any vibrating device will give off sound and our setup will detect it and/or datalog it. Not only that but for a few dollars it could be used in just about any industrial situation where vibrations may be destructive – such as engines, chassis, suspensions even buildings and bridges!

Data logging with waterfall analysis

The software will also enable you to do waterfall analysis and this is really a way of viewing a spectrum analysis as it varies over time.

It can be used as a datalogger for infrasound and audio signals. The vertical scale shows the frequencies of the various harmonics while the horizontal scale is time so the whole chart is a record of a few minutes.

TO SETUP FOR WATERFALL CHARTS

The wiring setup is virtually the same as for testing spectrum analysis microphone "Pre-champ" output (for voice prints)

The setup for the virtual instrument is:
Click on "preset"
Then "display"
Then "waterfall F2"
Then "rotate"
Then try different sweep times and resolution bandwidths (Res. Bw…..).
And try different colour schemes by clicking on "jet"
Press ***BMP*** to save the image you want.

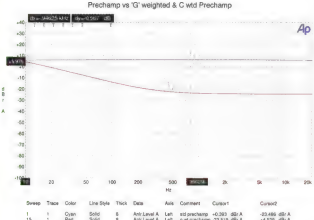
Setting up and operating the Virtual Analyzer

We assume you have downloaded the spectrum analyzer software from www.fatpigdog.com/spectrumanalyzer (or updated if you're using an older version).

The originator, Spyro Gumas, is very communicative and can assist if you have any problems.

To start, open and run the program. We used Windows XP but check the website first for compatibility with Vista, Windows 7, 8, etc.

Initially, you will see the black and white MS-DOS screen appear. You may have to wait (perhaps two minutes or so) and the instrument will appear similar to the trace below:



This sweep shows the frequency response of the modified preCHAMP: the top line is C weighted and is flat from 10Hz-20kHz. The middle line is an unmodified pre-CHAMP (not used) and bottom line (red) is the G-weighted response which joins the top line at 10Hz.Calibration can be carried out at 1kHz on the C setting and then is the same when the unit is switched to G, up to a max of 20Hz!

NOTE: Our Audio Precision analyser cannot go below 10Hz.

Once the virtual instrument pops up, plug the output from the prechamp into your soundcard mic input, switch to G weighting then set up as follows.You can attach the multimeter to the CHAMP output if you wish but in this case it is redundant.

On the virtual analyser:

Click on "reset" to clear any previous settings.
Click on frequency
Click on start (F2) and type in "0.5" <enter>.
Click on stop key (F3) and type "100" <enter> *(This sets the range to 0.5Hz-100Hz)*
Click on Lin/Log key (F4) so you see lin/(log) – *now the frequency range is set to a logarithmic scale.*
Then:
Click on bandwidth
Click on RBW and type in "0.5" <enter>
Click on sweep and type "10000" <enter>
Click on "trace" and then "max hold"

The analyser will then sweep continuously and indicate the number of averages at the top of the page.

The analyser is now ready to do a ten-second sweep of your sound source from 0.5Hz to 100Hz with a resolution of 0.5Hz and will continuously update itself with the maximum signal. For example we set it going during a thunderstorm to record the sound over a period of 20 minutes

You can save an image anytime by pressing "BMP" (bitmap).

You can play around with the RBW (resolution bandwidth) which you can set as low as 0.1Hz!

Refer to the fatpigdog manual provided if you have difficulty because some computers have different delay arrangements with the soundcard and you may need to compensate this with "tstupid".

When you are happy with a particular trace, you might like to activate the marker to examine point of interest.

Click on "marker" then "ON" and then click "peak". The marker will then indicate the dominant frequency

You will see a red dot appear on the trace, then move the marker to the area you want to measure by clicking on "<" (backward) or ">" (forward) keys.

The marker reading appears at the top of the page e.g "Mrk 2.558Hz, -86.2dB".

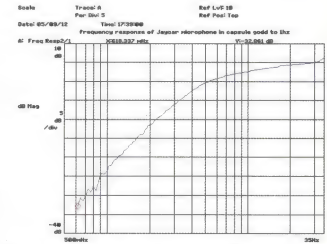
Once you have measurements of the points you are interested in, go to Table 1 and add or subtract the dB value at the frequency of interest. For example if you measured -10dB at 5Hz from the chart you have to ADD 5dB, ie -10+5=-5

Now during calibration, for our setup we found that -15dB on our spectrum analyser was 74dB SPL so we have to add 10dB (because -5dB is 10dB louder than -15dB).

So SPL=74+10
SPL=84dB

Accuracy

The figures quoted in this article are those achieved on a PC fitted with a generic sound card (ie, nothing special!) so we have every reason to believe that you should achieve similar results. However, no guarantees can be given! SC



This shows the actual frequency response of the finished setup using the Jaycar electret and is usable down to 1 Hz! You need to allow for falloff by using the table provided. Eg, for 1Hz you need to add 29dB to your base figure to obtain the correct SPL.

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Residual current device tester

This circuit was devised to test and display the trip time of an RCD (Residual Current Device or safety switch). It uses a PICAXE18M2 to perform all the necessary control and timing functions. It has a 2-line LCD panel to show the results and an optoisolated Triac circuit to provide the leakage test current.

A 9VAC mains transformer and bridge rectifier D1-D4 provide full-wave and half-wave unsmoothed DC to the supply voltage detector and the zero crossing detector. This arrangement provides a high degree of electrical isolation between the 230VAC and the PICAXE circuitry.

Transistor Q1 is the supply voltage detector. It is biased on by the 10kΩ resistor and the 47nF capacitor ensures that it remains on even when the unsmoothed DC falls to zero every half cycle. When the 230VAC supply is present, Q1 is turned on and when the supply is tripped, Q1 switches off quickly and its collector rises to +4.5V. This is monitored by the PICAXE to establish when the AC supply tripped.

Q2 is the zero crossing detector and it provides the PICAXE with a 50Hz square-wave signal and the rising edge of this signal is used by the PICAXE for starting the trip test.

The RCD test leakage current is provided by the Triac which is turned on by the optocoupler under the control of the PICAXE. The test current is limited to a little over 30mA by a 7.5kΩ 10W resistor. A lower power resistor could be used because it is only in circuit for less than 300ms but in the event that the RCD device fails to trip, the power dissipation is over 7W and would be excessive in a 5W resistor.

Phillip Weish is this month's winner of a $150 gift voucher from Hare & Forbes

The optocoupler includes an in-built zero crossing detection circuit that is technically unnecessary due to the zero crossing circuit described above, so it would be possible to substitute a non zero-crossing type. The optocoupler provides 5kV isolation between the 230VAC supply and the PICAXE control circuit.

Power for the PICAXE and LCD panel is supplied from three alkaline cells.

After plugging the tester's 230VAC cord into an RCD-protected power outlet, pushbutton S2 is pressed to start the test. At the first zero cross-

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NB: Requires a computer with DVD reader to view – will not work on a standard audio/video DVD player

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ing, the PICAXE switches the opto-coupler and hence the Triac, creating a leakage current from the Active of the 230VAC supply to mains Earth. At the same time, LED2 is switched on and the timing starts. When the RCD trips, LED2 extinguishes and the result in milliseconds is displayed on the LCD. LED1 indicates when the AC is on and is extinguished when the RCD trips. LED2 should be observed to pulse briefly during the trip period.

The first test commences at 0° on the AC waveform. A second test is normally undertaken after resetting the RCD that will delay the trip start by one half cycle or 180°. This arrangement tests the RCD trip coil on both rising and falling waveforms, as required by AS/NZS 3760 (in-service safety inspection and testing of electrical equipment).

Subsequent tests indicate the trip time measured in the number of full 50Hz cycles starting at zero and then 180° (note: this provides lower accuracy as tripping part way through a cycle counts as a full cycle).

The circuit has been tested with two RCDs that were also tested with an expensive commercial RCD tester and the results compare very favourably. The accuracy of this tester appears to be better than 10ms. AS/NZS 3760 indicates that a 30mA RCD maximum tripping time is 300ms (15 cycles at 50Hz).

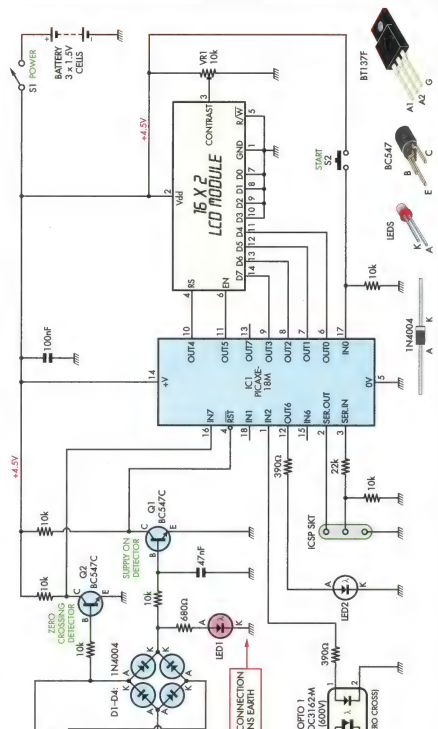
My experience is that most RCDs will trip in much less than half that time. Given the accuracy of this tester, any RCD that is tested using this circuit that gives a trip time of more than say 290ms should be failed or check-tested with a commercial test unit.

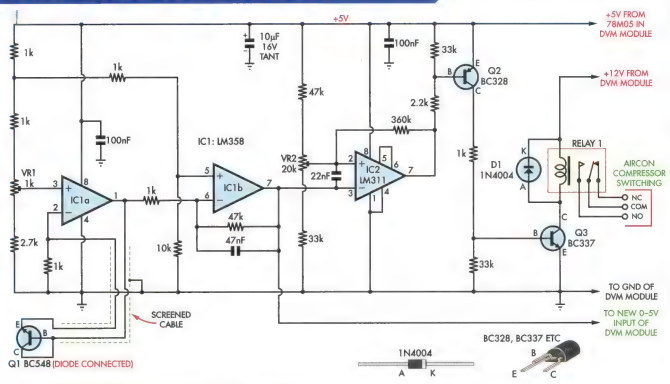
To calibrate the time measurement software, a PICAXE08M2 was configured to simulate a RCD over a range of trip times.

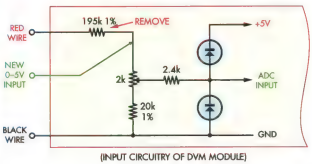
The software, *RCD Code.bas*, is available on the SILICON CHIP website.

Phillip Webb,
Hope Valley, SA.

Editor's note: the BT137F Triac could be omitted from the circuit, leaving the MOC3162-M to directly switch the current through the 7.5kΩ 10W resistor (ie, 390Ω resistors not required). This should not be a problem since it has a continuous current rating of 60mA. It is also possible to use the unit at lower test currents by using a higher value in place of the 7.5kΩ 10W resistor.







Airconditioner controller for cars

While "climate control" is a feature of the airconditioner in many modern cars, whereby the cabin operating temperature can be set, older model cars do not have this advantage. However, adding this controller circuit can provide a settable cabin temperature for the aircon in older cars.

It uses a diode-connected transistor and exploits the variation of the forward voltage of a silicon junction in response to temperature at the rate of -2mV/°C, ie, the voltage is reduced by 2mV for an increase in temperature of 1°C. The temperature is displayed on a standard LCD voltmeter module and can be set to turn the compressor relay on and off at a preset value, eg, 25°C.

Op amp IC1a is connected so that its output voltage varies in direct proportion to the temperature monitored by NPN transistor Q1 which has its base connected to its collector. The output of IC1a is then amplified by IC1b to drive a digital voltmeter module with a range of 0-5V (corresponding to 0-50°C).

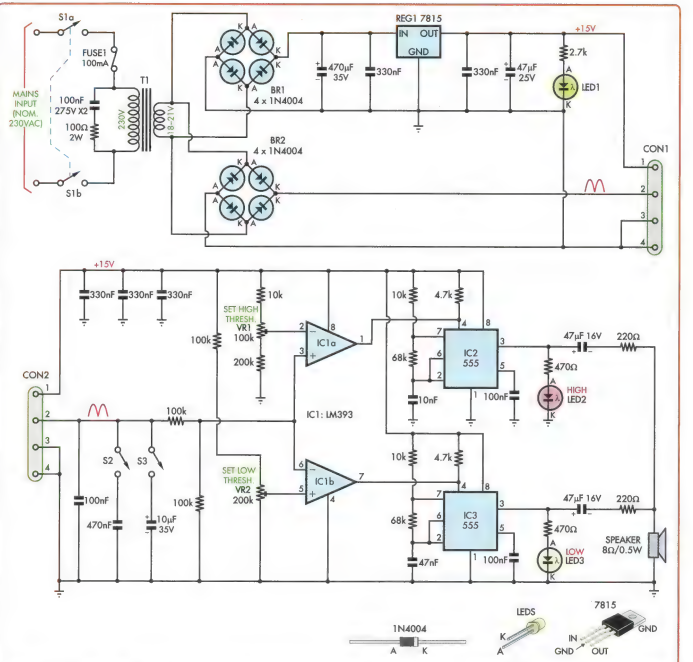
The voltmeter is sourced from a Chinese supplier (via ebay). As supplied, it is a 0-50V unit and it needs to modified by removing a 195kΩ multiplier resistor so that it can be calibrated to read up to 5V DC.

IC2, an LM311 comparator, monitors the temperature output of IC1b and compares it with a reference voltage from the wiper of potentiometer VR2. If the voltage at pin 3 is above the reference voltage at pin 2, meaning the temperature is above the preset, the output at pin 7 of IC2 will go low, turning on Q2 and Q3 and thereby energising the relay to turn on the airconditioner's compressor.

As the temperature in the cabin drops below the preset, the voltage from pin 7 of IC1b also drops and IC2's output goes high, turning off Q2 & Q3 and switching off the relay to turn off the compressor.

Note that any DVM module could be similarly modified, provided that it could then directly read a temperature range up to, say, 30°C. The 5V and 12V rails for the circuit come from the modified 50V DVM module and if another module was substituted, you may need to obtain the 12V rail from the car's 12V battery and the 5V rail via an LM2940 5V regulator.

John Russull,
Bangkok, Thailand. ($60)



High & low mains voltage alarm

While there are good reasons for wanting a low mains voltage alarm to warn of brownouts (to avoid possible damage to induction motors in pumps and compressors in airconditioners, refrigerators etc), there is now a need for a high mains voltage alarm. The main reason for this is that grid-connected solar power systems can jack up the voltage to quite high and possibly damaging levels during the day when power demand in a local area may be low. Such high voltages can damage electronic equipment, if it exceeds 250VAC.

Commercial mains voltage analysers are expensive and not readily available so a cheap warning alarm can be quite useful. This circuit can warn of high or low AC mains voltages and has adjustable alarm levels.

Transformer T1 drives bridge rectifiers BR1 & BR2, each consisting of four 1N4004 diodes. The output of BR1 is filtered and fed to REG1, a 7815 15V regulator, to provided a 15V DC supply to the three ICs in the circuit. Bridge BR2's output is unfiltered and is fed (via connectors CON1 & CON2) to a voltage divider consisting of two 100kΩ resistors. The resultant voltage is then fed to the inputs of an LM393 dual comparator (IC1) which is connected as a "window comparator". This enables it to sense high and low voltage conditions.

IC1a is the "high" comparator and has a preset reference voltage fed to its pin 2 inverting input from trimpot VR1. Similarly, IC1b is the "low" comparator and has a preset voltage fed to its pin 5 non-inverting input from trimpot VR2. These preset reference voltages are compared

continued on page 44

Soft start for 6/12V toy car motors

This circuit was devised to prevent extreme acceleration of a 6V tricycle at switch-on. It could be use to prevent similar problems in any battery-operated toy car. It provides a start delay of about 250ms and was found to provide much more gentle acceleration when power is first applied.

Two different versions of the circuit are shown, one using a P-channel Mosfet and the other using an N-channel Mosfet, although both work along the same lines.

Fig.1 shows the P-channel version. When power is applied via pushbutton S1, the 47µF capacitor is charged at a variable rate set by trimpot VR1, increasing the gate voltage of Mosfet Q1 (IRF9540) from zero to initial conduction at about -3.6V through to full conduction at about -4.2V (with respect to the source of Q1).

High-resistance settings of VR1 give more delay but limit the current which can ultimately be delivered to the motor. A little fiddling with VR1 will soon establish a reasonable balance between the two. The 100kΩ resistor slowly discharges the 47µF capacitor when S1 is released.

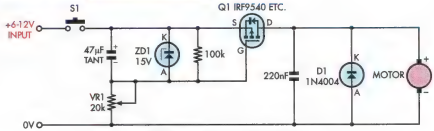


FIG.1: USING A P-CHANNEL MOSFET

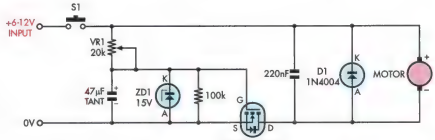


FIG.2: USING AN N-CHANNEL MOSFET

Little children often press buttons repeatedly with a "stabbing" motion during the learning process rather than press and hold, and in this application the slow gate voltage drop allows quicker FET turn on for smoother restoration of speed – in other words you don't want rapid gate switch-off.

Fig.2 shows the N-channel version, using an IRF540, a preferred device given its I_{DS} of 33A and a very low R_{DS} "on-resistance". With either version, if the toy draws heavy current, a heatsink will need to be fitted the Mosfet.

Colin O'Donnell,
Glenside, SA. ($30)

High & low mains voltage alarm – continued from p43

to the unfiltered DC fed to the other comparator inputs. If the mains voltage is low, IC1b's output at pin 7 will go high and enable 555 timer IC3 (by pulling its pin 4 high). IC3 then oscillates to give an audible alarm via the loudspeaker and it lights LED3.

If the mains voltage is high, IC1a's output at pin 1 goes high, enabling 555 timer IC2 which then oscillates and drives the speaker. It also lights LED2. Note that the tone from IC2 is 4.7 times higher in frequency than the tone from IC3 so that it is easy to distinguish between the high and low voltage alarms.

Switches S2 & S3 can be switched in to provide filtering of the unsmoothed DC (from BR2) that's monitored by the two comparators and thereby vary the speed at which the circuit responds to out-of-limit voltage conditions.

Trimpot VR1 can be set to provide an alarm when the mains voltage exceeds 250VAC (say) while trimpot VR2 can be set to provide an alarm when the mains voltage drops below 200VAC.

Petre Petrov,
Sofia, Bulgaria. ($50)

MAY THE BEST contribution WIN!

As you can see, we pay $$$ for contributions to Circuit Notebook. Each month the BEST contribution *(at the sole discretion of the editor)* receives a **$150 gift voucher from Hare&Forbes Machineryhouse**. That's yours to spend at Hare&Forbes Machineryhouse as you see fit – buy some tools you've always wanted, or put it towards that big purchase you've never been able to afford!

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or post to PO Box 139, Collaroy NSW

Jaycar Electronics

Better, More Technical

MARCH EDITION

Prices valid until 29/03/2013

Amazing "Black Box" Car Multifunction Unit

This 5" touch screen LCD fits onto the windscreen in a very similar fashion to a GPS. A video camera on its reverse side can record what you see through your windscreen. It also has a GPS navigation function, however no mapping software is supplied with the unit. This can be purchased directly from GPS mapping solution companies easily over the internet. Supplied with all relevant leads and window screen bracket.

- Includes: Built-in GPS antenna, MP3 player, a video player, a photo viewer, calculator/calendar, FM radio, MINI USB port and has windows CE
- Supports Micro SD/MMC card (From 1GB up to 8GB)
- Built-in Lithium battery
- Size: 134(W) x 83(H) x 13(D)mm

QV-3812

NEW $169.00

Wireless Tyre Pressure Monitoring Kit

Uneven or inadequately inflated tyres can cause steering alignment problems. This device fits 4 sensors to your tyre stems that feed PSI data to a 12VDC monitor inside the car helping you to know when you need to take action to inflate them back to a desired level.

- Suitable for vehicles designed for 30-42PSI
- High & low pressure alarm
- Sensor size: 23.5(Dia.) x 15(H)mm

QP-2298

NEW $199.00

Line Interactive UPS - 360W 650VA

Protect valuable computer systems and critical data from black outs and power surges. Constantly monitors the mains supply and switch to battery power to enable the system to be shut down without data loss. Supplied with a 7Ah SLA battery for 3 minutes back-up time at full load, USB interface cable and software. See website for full specs.

- Power rating: 650VA at 240VAC
- Size: 382(L) x 124(W) x 225(H)mm

MP-5201 *was $129.00*

$99.00 SAVE $30

Our 2013 Engineering & Scientific Catalogue is available next month! Get it FREE with April Silicon Chip Magazine or at your local store for only $3.95

2.4GHz DIGITAL Wireless Speakers

Pop this pair of speakers in the backyard and the 2.4GHz DIGITAL audio transmitter will send crystal clear audio to the units up to 30m away. Each speaker has its own power adaptor and operates wirelessly. Power adaptor for transmitter and speakers are included, however speakers can also be powered via 6 x AA (not included) for complete portability.

- Speaker size: 250(H) x 130(Dia.)mm

AR-1891 *was $169.00*

$129.00 SAVE $40

Vacuum Bench Vice

A robust bench vice with a powerful suction base. The jaws have V grooves for holding cylinderical or irregular shapes.

- Size: 160mm tall, 75mm jaw

TH-1766 *was $29.95*

$19.95 SAVE $10

Weather Station with Clock & Photo Frame

Keep tabs on the weather and time or display photos. A remote sensor sends data to the display unit, which provides temperature, humidity, trend and forecast information. It also displays indoor temperature. Photos can be loaded by a host PC, via SD/MMC card or USB flash drive. Mains plugpack included.

- 12/24 hour clock with alarm
- Time and date display with DST and time zone
- Wall or desk mount
- Size: 200(W) x 150(H) x 30(D)mm

XC-0345

was $159.00

$99.00 SAVE $60

In-Car FM Transmitter Kit

Plugs in-line with car's antenna to transmit clear and drift-free stereo audio from a Smartphone or MP3 player through the FM radio in your car. Features a USB socket to charge the device while driving. Charging cable for iPhone® and 1m 3.5mm audio cable is included.

- In-line antenna connection
- Power input 12 - 24VDC

AR-3104

NEW $59.95

Thomastown Store

225B Settlement Rd

Thomastown

VIC 3074

(03) 9465 3333

Intelligent GSM Wireless Alarm System

Incorporates a quad band GSM module which provides phone and SMS notification (GSM Sim card not included) when the alarm is triggered. Utilises wireless PIR detectors and reed switches and features up to nine zones, remote arm and disarm function and battery backup. Supplied with alarm control unit, loud 120dB siren, and a wireless remote control.

- Alarm trip notification via GSM network no phone lines required
- Notifies up to three programmed numbers by phone and SMS
- Mains power supply included
- Wireless range of 50m
- Alarm panel size: 119(H) x 176(W) x 29(D)mm

LA-5156

NEW $299.00

2 x 100WRMS Stereo Amplifier

Rated at a generous 100WRMS per channel and has a flat frequency response from 20Hz to 20kHz. Includes remote control to adjust input source, volume, etc.

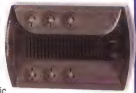
- Inputs for Tape, Tuner, AV1, AV2, CD, Phono
- Size: 420(W) x 135(H) x 214(D)mm

AA-0470 *was $199.00*

$169.00 SAVE $30

To order call 1800 022 888 **www.jaycar.com.au**

Line Interactive UPS - 300W 600VA



Keep devices running for up to 5 minutes so you can shutdown safely without damaging equipment or losing data. Features full automatic voltage regulation, voltage overload/sag protection, surge protection and more. See website for details.

NEW $99.00

- Output waveform: Sine Wave (Mains), Modified Sine Wave (Battery)
- Size: 280(W) x 185(D) x 95(H)mm

MP-5224

DUE EARLY MARCH

2.5"/3.5" SATA Dock with Offline Clone Function

This dual SATA dock will accept 2 x 2.5" or 2 x 3.5" (or one of each) SATA HDDs/SSDs. Just dock a drive with a complete install of an operating system, and press the big red clone button. It can also be used as a regular SATA dock for quickly grabbing data off your collection of SATA drives.

- Size: 125(L) x 112(W) x 60(H)mm

XC-4695 *was $79.95*

$49.95 SAVE $30

Hard drives not included

2 x USB 3.0 Port Upgrade Kit

Add two USB 3.0 ports to the front of your desktop PC for compatibility with the next generation of superfast USB 3.0 hard drives, flash drives and other assorted peripherals. The front panel will fit neatly into the 3.5" FDD slot of most PC cases.

XC-4147 *was $49.95*

$39.95 SAVE $10

Limited Stock.

Foldout Twin-Fan Notebook Cooling Pad

Helps keep a notebook from overheating. Made from strong steel construction that folds down into a compact little package. Suitable for any size laptop.

$9.95

- Foldout size: 275(W) x 183(D) x 17(H)mm

XC-5216

USB 2.0 DVD Maker II

Connect your VHS player, then connect to your PC or MAC® and use the included software to capture, edit and burn your videos to DVD or upload to the web.

- Composite video input via RCA connector or S-Video mini-DIN
- Size: 35(W) x 95(D) x 15(H)mm

XC-4867 *was $69.95*

$59.95 SAVE $10

USB RJ45 Extension Adaptor

Connect USB devices to a computer from up to 50m away via a standard Cat 5 network cable.

- PC and MAC® compatible
- Requires standard Cat 5 cables
- Supports USB 1.1
- Transmitter and receiver included

XC-4884 *was $39.95*

$29.95 SAVE $10

KVM Switch

Keyboard Video Monitor (KVM) switches allow you to use one keyboard, mouse and monitor to control several computers.

- 2-port USB
- Max resolution: 1920 x 1440 pixels
- Video bandwidth: 400MHz

YN-8093 *was $69.95*

$59.95 SAVE $10

Compact USB2.0 Card Reader

Small enough to attach to your keyring, this USB multi-card reader accepts a wide variety of popular formats. Simply fold out the USB adaptor, fold back for easy storage or travel.

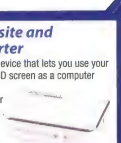
- Supported card formats: MS/MS Pro Duo/M2/T-Flash /MicroSD /SDHC/SD/MMC/RS MMC/Mini SD
- Size: 40(L) x 34(W) x 15(H)mm

XC-4749

$12.95

VGA to Composite and S-Video Converter

A compact and versatile device that lets you use your wide screen plasma or LCD screen as a computer monitor for gaming or presentation use. Great for watching DVDs, gaming, presentations, or just having a big screen on your computer. No software is required. See website for full specifications.



- Up to 1024 x 768 resolution
- USB powered
- Size: 90(L) x 70(W) x 25(H)mm

XC-4871 *was $89.95*

$69.95 SAVE $20

ANTENNAS

2.4GHz Antennas

Improve the range of your wireless network. Specifically designed for 2.4GHz and 802.11 wireless network applications.

FROM $19.95

- Detachable magnetic base

5dB Gain 195mm length AR-3273 $19.95
11dB Gain 380mm length AR-3277 $39.95

3G/4G Antennas

Using 3G/4G wireless Internet in certain areas may require the help of an antenna to boost the signal for a reliable flow of data. Features a strong magnetic base so you can fix it to the roof of your car and support frequency ranges of 850, 1900, 2100MHz.

- Terminated with an FME connector

FROM $49.95

5dBi 2m Cable AR-3310 $49.95
7dBi 3m Cable AR-3312 $69.95

Laptop Power Supplies

Ideal spare or replacement power supplies for on-the-go or just at the office. Compatible with most notebooks on the market. Check our website for compatibility. Automatic voltage select.

MP-3320

$49.95 SAVE $10

70W Universal

- 16 plugs

MP-3320 *was $59.95*

MP-3328

$99.00 SAVE $30

120W Universal

- 13 plugs

MP-3328 *was $129.00*

VGA/Audio Splitters

Splits a computers VGA and audio signal to two identical streams. The splitter provides fast, flexible solutions for test bench facilities, data centres or video broadcasting.

- Includes a 1.8m male to female VGA cable

2 Port VGA/Audio Splitter

- Bandwidth up to 500MHz
- Size: 125(W) x 25(H) x 72(D)mm

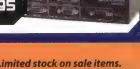
YN-8075

$69.95

4 Port VGA/Audio Splitter

- Bandwidth up to 500MHz
- Size: 165(W) x 46(H) x 98(D)mm

YN-8076



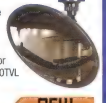
$99.95

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/03/2013.

SECURITY & SURVEILLANCE

Hidden Camera Mirror

Designed for use where concealed high security is the main requirement such as retail stores, offices, ATMs, museums etc. Looks like a simple concave security mirror but embedded behind is a 600TVL security camera.



- Image sensor: 1/3" colour Ex-view CCD
- Size: 350(Dia.) x 200(H)mm

QC-8631

NEW $199.00

ACCESS CONTROL

Universal Fingerprint Access Controller

A complete bio access control solution that enables you to enrol up to 120 users. It reads in less than two seconds. It has a robust cast housing and all operating parameters are stored in a flash memory so it won't be lost due to power failure.

- Weatherproof and tamperproof
- IR remote control
- Up to 4 supervisors
- Power supply: 12VDC
- Size: 68(W) x 115(H) x 32(D)mm

LA-5122 ***was $399.00***

$99.00 SAVE $200

Non-Contact Infrared Door Exit Switch

The sensor will trigger an internal relay when your open hand comes within 100mm of the panel. Perfect for triggering exit doors etc. 12VDC supply required.

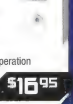
- 3A @ 30VDC contact rating
- 30mm sensor diameter
- Plate size: 70 x 115mm

LA-5187 ***was $59.95***

$49.95 SAVE $10

Motion Sensor Alarm with Solar Panel

Simple and easy to use alarm. It triggers the siren once movement is detected up to 8m away. The solar panel is sufficient for daytime arming and uses backup battery power for night time.



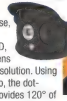
- 130dB siren
- 3 x AA batteries required for night operation
- Mounting hardware included
- Size: 116(H) x 70(W) x 33(D)mm

LA-5216

$16.95

Weatherproof IR Day/Night Camera

Housed inside a weatherproof case, with the latest dot-matrix IR LED, a fixed 3.6mm lens and a 600TVL resolution. Using only a single chip, the dot-matrix IR LED provides 120° of horizontal coverage and produces an infrared light output equivalent to the combined output of many ordinary IR LEDs, turning night into day.



- Image sensor: 1/3" Colour HDIS CMOS
- Size: 155(L) x 87(W) x 73(H)mm

QC-8627

NEW $99.95

Solar Wireless PIR Announcer

Monitors areas wirelessly with this solar wireless PIR motion detector. It comes with a solar panel which mounts on the roof and connects to the sensor to ensure very long battery life. Use as a driveway entry alert, garage or shed alarm or door entry and backyard announcer. Easy to install and mounting hardware is included.

- Detection range 4-5m
- Announcer requires 4 x D batteries
- Announcer size: 143(H) x 121(W) x 53(D)mm
  PIR size: 110(H) x 75(W) x 60(D)mm
  Solar panel size: 124(H) x 174(W) x 14(D)mm

LA-5174 ***was $79.95***

$69.95 SAVE $10

40m Vari-Focal Pro IR Camera

A quality camera ideal for long range outdoor surveillance. It captures images up to 40 metres away in total darkness. IP66 rated with aluminium casing. Supplied with sun hood, mounting bracket and hardware. See website for full specs.

- Sony® Super HAD sensor
- 42 colour IR LEDs (can be switched from low, medium or high illumination)
- 12VDC, 840mA max
- Size: 180(L) x 106(W) x 110(H)mm excluding bracket

QC-8613 ***was $399.00***

$349.00 SAVE $50

SECURITY LIGHTING

Solar Powered 3W LED Sensor Lights

A fully self sustained lighting kit, perfect where mains power is unavailable. It uses high powered CREE® LED lights to provide a bright focused beam of light to illuminate driveways, backyards etc. Exceptionally low power requirements mean the waterproof solar panel keeps the rechargeable batteries topped up. Very easy to install.

SL-2707

SL-2709

- Mounting hardware included
- Adjustable swivel head

FROM $64.95 SAVE $15

1 x 3W LED

- 108 lumens output

SL-2707 ***was $79.95 now $64.95 save $15.00***

2 x 3W LED

- 240 lumens output

SL-2709 ***was $99.00 now $79.00 save $20.00***

Limited stock. Not available online.

Wireless MP3 Doorbell

With wireless technology, this unit can use your favourite song or any recording saved in MP3 format as your door bell. Connect to PC by USB, install the software pre-loaded into the unit then select, trim and save your MP3 file and away it goes.

- Up to 100m transmission range
- Requires 3 x AA batteries for the main unit
- Supplied with 1 x CR2032 battery for the door bell

LA-5024

$44.95

Wireless Intercom Doorphone

A compact wireless intercom/doorphone with 2.4GHz DIGITAL transmission for crystal clear and interference free range up to 100m range. Comes with 240V mains charger.

- Traditional ding dong sound
- Portable indoor unit
- Weatherproof outdoor unit
- Two way interference free intercom
- Outdoor unit: 135(L) x 95(W) x 30(H)mm
- Indoor unit: 115(L) x 67(W) x 35(H)mm

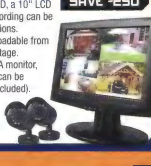
AM-4332 ***was $79.95***

$69.95 SAVE $10

BARGAIN OF THE MONTH

Network 4 Channel 10" LCD DVR and Camera Kit

This 4 channel network DVR has a 320GB HDD, a 10" LCD and 2 x 350TVL cameras. Easy to install! Recording can be started manually or by triggered alarm conditions. Smartphone support and iPhone® app downloadable from iTunes® available to view live or recorded footage. Monitoring may be done in real-time on a VGA monitor, LAN, iPhone® or Smartphone. DVR functions can be controlled by the mouse or IR remote (both included).



- DVR size: 208(L) x 85(W) x 242(H)mm
- Camera size: 115(L) x 45(H)mm

QV-3030 ***was $699.00***

$449.00 SAVE $250

10 Zone Alarm Kit

Fully configurable and programmable. Includes a central controller and the sensors you need to get a basic system up and running. Up to four remote keypads can be installed at up to 100m range and each can be named for easy identification.

- 10 programmable zones
- 4 access levels
- Programmable timers for entry, exit and alarm duration
- Kit includes: control panel, LED controller, PIR sensors, reed switch, bellbox, 50m 6 core cable and 12V 1.2Ah backup battery

LA-5560 ***was $299.00***

$199.00 SAVE $100

3 Speed Turntable with Speakers & Audio Output

Listen to vinyl collections directly from the unit and its built-in speakers. Features a 3.5mm headphone jack, adjustable bass control and a line level output for connection to an external amplifier.

- Mains powered
- 33/45/78 RPM
- Stereo amplifier
- Size: 350(L) x 310(D) x 130(H)mm

GE-4136 **$59.00**

CD to USB/SD Encoder with Clock & Radio

Play and digitally encode your old CD or cassette tape collection straight to SD card or memory stick as MP3 files.

- AM/FM digital tuner with clock function
- Built-in amplifier and stereo speakers
- USB / SD card reader
- Requires 2 x AAA batteries
- Size: 250(W) x 204(D) x 85(H)mm

GE-4138 **$69.00**

Remote Control Audio/Video Selector Switch

Connect up to 4 AV sources to one television and switch between them remotely. Features 4 x RCA composite/S-Video inputs and 1 x RCA composite/S-Video output.

- Size: 190(L) x 115(W) x 50(H)mm

AC-1654 **$44.95**

Remote Control AV Selector

This device eliminates cable hassles, using the Remote AV Selector you can add up to 3 AV sources to your Home theatre's AV inputs. Easily switch between devices like DVD players, satellite receiver or game consoles. See website for full specifications.

- DC Power Jack
- 9VDC / 500mA power
- Size: 240(L) x 110(W) x 51(H)mm

AC-1674 ***was $89.00*** **$59.00** SAVE $30

Flat Panel Digital Antenna with Amplifier

Capable of picking UHF and VHF signals as well as DAB+ radio signals. Features 2 adjustable antennas and a standard PAL adaptor as well as a separate amplifier which may be required for areas with weaker indoor reception.

- VHF Frequency: 45-230MHz
- UHF Frequency: 470 - 862MHz
- Panel size: 480(L) x 109(W) x 54(D)mm

LT-3156 NEW **$39.95**

Indoor Digital TV Amplifier UHF/VHF

A portable and compact amplifier capable of boosting signals to indoor TV antennas for both digital and analogue signals. It can be powered from mains or USB (mini plug available separately) and features manual UHF/VHF gain adjustors to give you greater control over your signal. Standard PAL connections.

- HF Frequency: 45 - 230MHz
- UHF Frequency: 470 - 862MHz
- Size: 100(L) x 60(W) x 27(H)mm

LT-3281 NEW **$24.95**

70mm Flat Panel "exciter" Speaker

This "exciter" speaker produces audio waves by vibrating the flat panel it is fixed to. Install it on ceiling panels, under a table, on a wall partition, behind a fibreglass panel or other flat surface where a conventional speaker can't normally be used.

- 15WRMS @ 8 ohms
- Size: 70mm(Dia.) x 20(D)mm

AS-3039 NEW **$14.95**

Portable Practice Amp

Feature packed with 32 built-in live rhythm drum patterns, volume, gain, distortion, overdrive and tone controls. AUX-IN jack to connect a CD/MP3 player and jam with your heroes.

- Headphone jack for private practice
- Built-in E-string tuner
- 2W Mono speaker
- Requires 1 x 9V battery for up to 8 hours play
- Size: 180(L) x 90(W) x 155(H)mm

CS-2553 ***was $119.00*** **$99.00** SAVE $20

WATCH VIDEO ONLINE

Microphone Intercom Speaker

Designed for box office style communication through protective glass such as ticket booths, bank counters, reception desks, or nightclub entry points. It features an adjustable gooseneck and volume adjustable rotary button at the base.

- Requires 2 x AA batteries
- Uni-directional electret condenser
- Size: 98(H) x 66(W) x 25(D)mm

AA-4089 ***was $99.00*** **$79.00** SAVE $20

Charge/Sync Keyring to suit iPhone®/iPad®

Attach to your keyring for a convenient way to charge or sync your iPhone®, iPad®, or iPod®. Looks like a standard car remote but inside is a USB plug and a standard iPhone® connector.

- Size: 49mm long

WC-7697 NEW **$9.95** Keyring & keys not included

ACCESSORIES TO SUIT APPLE® PRODUCTS

AV Component Lead

iPhone® not included

Connect an Apple® device to HDTV, projector or home theatre system via the Component RCA input. Features a USB connection to charge the Apple® device. See online for compatibility.

- Cable length: 1.5m

WC-7699 ***was $44.95*** **$34.95** SAVE $10

AV Docking Station

Share and play music, pictures and videos from your iPod® or iPhone® on a TV, monitor or home audio system. Includes dock with charge port, full function IR remote control, AV & USB cables.

- Composite video and stereo audio output
- Size: 88(W) x 74(L) x 19(H)mm

iPhone® not included

WC-7715 ***was $49.95*** **$39.95** SAVE $10

HDMI Converter

Share and play favourite songs, videos and photos on a TV or monitor from an Apple® device via HDMI. Sync and charge via USB port.

- Video resolution 720p
- Compatible with iPad® 1 & 2, iPhone® 4/S, iTouch® 4th Gen
- Size: 157(L) x 116(W)mm

WC-7713 **$49.95**

Active 5" Speakers with USB

Provides 30WRMS per channel with inputs either via line-level RCA or USB, so it will accept memory sticks or any other USB device. Add an MP3 player for a complete digital music system. Perfect for your next patio party.

- Sold as a pair
- Mounting brackets included
- Size: 180(W) x 235(H) x 180(D)mm

CS-2437 ***was $199.00*** **$169.00** SAVE $30

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/03/2013.

POWER & LIGHTING

Portable Power Bank - 5000mAh

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GU10 Mains Cool White	ZD-0625
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NEW $29.95 ea

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- Uses 433MHz to wirelessly transmit data
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MS-6167 *was $179.00*

NOTE: Only works with NET-METER grid-connect solar systems.

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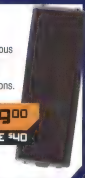
ZM-9045 *was $129.00*

$89.00 SAVE $40



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SL-2711 *was $34.95*

*Based on 20 seconds of light, 15 times per day using an alkaline battery

$29.95 SAVE $5

NO.1 FOR KITS

Soft Start Kit for Power Tools

Ref: Silicon Chip Magazine July 2012

Stops that dangerous kick-back when you first power up an electric saw, router or other mains-powered hand tool. This helps prevent damage to the job or yourself when kick-back torque jerks the power tool out of your hand. Kit supplied with PCB, silk screened case, 2m power cord and specified electronic components.

- 240VAC 10A
- PCB: 81 x 59mm

KC-5511

$49.95

USB Power Monitor Kit

Ref: Silicon Chip Magazine December 2012

Plug this kit inline with a USB device to display the current that is drawn at any given time. Check the total power draw from an unpowered hub and its attached devices or what impact a USB device has on your laptop battery life. Displays current, voltage or power, is auto-ranging and will read as low as a few microamps and up to over an amp. Kit supplied with double sided, soldermasked and screen-printed PCB with SMD components pre-soldered, LCD screen, and components.

- PCB: 65 x 36mm

KC-5516

$59.95

Jacob's Ladder MK3 Kit

Ref: Silicon Chip Magazine February 2013

A spectacular rising ladder of bright and noisy sparks for theatre special effects or to impress your friends. This improved circuit has even more zing and zap than it's previous design from April 2007 and requires the purchase of a VS Commodore 12V ignition coil (available from auto stores and parts recyclers). Kit supplied with silk-screened PCB, diecast enclosure (111 x 60 x 30mm), pre-programmed PIC, PCB mount components and pre-cut wire/ladder. Powered from a 12V 7Ah SLA or 12V car battery.

KC-5520

NEW

$49.95

Battery not included

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- Reset button

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NOTE: Can for comparison only.

Jaycar High-Power Class-D Audio Amplifier Kit

Ref: Silicon Chip Magazine Nov/Dec 2012

High quality amplifier boasting 250WRMS output into 4 ohms, 150W into 8 ohms and can be bridged with a second kit for 450W into 8 ohms. Features include high efficiency (90% @ 4 ohm), low distortion and noise (<0.01%), and over-current, over-temperature, under-voltage, over-voltage and DC offset protection. Kit supplied with double sided, soldermasked and screen-printed silk-screened PCB with SMD IC pre-soldered, heatsink, and electronic circuit board mounted components.

- Power requirements: 57V/0/+57V (see KC-5517)
- PCB: 117 x 167mm

KC-5514

$89.95

Also available:

Stereo Speaker Protector Kit to suit KC-5515 $29.95

+/- 57V Power Supply Kit to suit KC-5517 $29.95

Mains Timer Kit for Fans and Lights

Ref: Silicon Chip Magazine Aug 2012

This simple circuit provides a turn-off delay for a 230VAC light or a fan set to run for a short period after the switch has been tuned off. The circuit consumes no stand by power when load is off. Kit supplied with PCB, case and electronic components. Includes 100nF capacitor for 1 min to 20 mins. See website for a list of alternate capacitors for different time periods.

- Handles loads up to 5A
- PCB: 60 x 76mm

KC-5512

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Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details.

Prices valid from 24th February 2013 to 23rd March 2013.

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We "road test" Blamey & Saunders' new SIE-64 Digital Hearing Aids

Back in our July 2011 issue, readers may recall a feature on some new, low cost hearing aids from an Australian company, Australia Hears.

In a nutshell, we'd heard about some new Aussie hearing aids which were a fraction of the price of those currently on the market and wanted to try them out.

And we came away more than impressed – so much so that I bought a pair and have been using them ever since.

At the time, we said it was rather unusual for a magazine such as SILICON CHIP to be "reviewing" hearing aids but from the letters and phone calls we received after publication, readers were most appreciative – and many told us they'd purchased hearing aids either for the first time or as replacements for aids they weren't happy with.

Nearly two years later, the company name has changed (apparently for legal reasons) to Blamey and Saunders Hearing Pty Ltd, reflecting the two principals of the organisation – Professor Peter Blamey and Dr Elaine Saunders, both internationally-regarded experts in the field of audiology.

But even more importantly, they've added a new model to their line-up, the SIE-64.

It's smaller than the previous models and as its name suggests, is a speaker-in-ear model (hence SIE) with 64 frequency channels versus the 32 channels of the models we tried out.

While it is more expensive (and we'll cover that shortly) the SIE-64 has been getting the proverbial "rave reviews" from users, even those who were converts to the earlier Blamey&Saunders models.

Incidentally, when I reviewed the hearing aids I had the choice of either the LOF (Liberty Open Fit) or the SIE (speaker in ear) models but I couldn't find much between them.

However, I purchased the LOF models – not *just* because they were $260 each cheaper than the SIE-32s but mainly because they offered the option of Telecoil operation.

by Ross Tester

Don't know what we're talking about? Telecoil is a system which offers enhanced performance to hearing aid users in many public buildings (and can also be fitted to telephones).

There's a series of DIY articles in SILICON CHIP from September 2010 through March 2011 which will help you understand what it's all about.

But you want to know something? Apart from playing with Telecoil when I initially got the hearing aids, I've never used it in anger. The hearing aids themselves did such a great job of pulling speech (particularly) "out of the mud" especially in public areas and meetings, I didn't feel the need to invoke the Telecoil function.

It was one of those "manāna" things – tomorrow, maybe!

I was delighted at the way the things worked – and being a person who had quite a number of meetings to attend,

The three models in the range: the new SIE (speaker-in-ear) 64 (left) and 32 (centre), with the LOF (liberty open fit) at right. As you can see, the two SIE models are fairly close in size while the LOF is a bit larger. All feature digital technology with quite advanced features – and the best part of all is the prices, especially when you compare them to others on the market.

I had far better comprehension when someone up the back was speaking softly.

The other biggie, at least as far as my partner was concerned, was the need NOT to have the TV or radio wound up to ridiculous (to her!) levels. Now I'm quite happy to have it at a comfortable level for her – and there has been a pleasant side effect.

I've been complaining for years about the "muffled" sound quality of many TV programs, particularly where any form of accent is concerned. The English panel program "QI" (which both of us find quite interesting . . .) is a case in point.

But with the hearing aids, I've found a rather significant increase in clarity and hence comprehension. She's more than happy that "woddeysay?" has all but disappeared from my lexicon.

So that was my experience with the Blamey&Saunders LOF hearing aids: very happy! Blamey&Saunders must have been happy with my reaction to them (and, apparently, quite a few sales as a result of the article).

So much so that they not only advertised their new models in SILICON CHIP (obviously they recognised a significant portion of the SILICON CHIP readership was their target market), they also offered me the opportunity to "road test" the SIE-64s.

As I commented in the earlier article, I paid full price for the originals – so who was I not to take them up on their offer!

SIE-64 observations

The first thing I noted was the difference in size – at 23 x 10 x 6mm, the '64s are about 30% smaller than the LOF models (34 x 14 x 8mm) and slightly smaller than the SIE-32s (25 x 14 x 8mm); they take a smaller battery (size 312 vs size 13) and in fact are half the weight – 2g vs 4g – not that I noted much difference in use.

But as I mentioned earlier, the major difference is a significant upgrade in technology, with 64 frequency channels (both the LOF and SIE-32s have 32 channels) and much better battery life over the SIE-32s (at 150+ hours, they approach the life of the LOFs and are half as much again as the SIE-32s).

What difference does 64 channels make?

The sounds we hear in the real world are a complex mixture of smaller sounds. The world of sound is made up of dull thuds, high pitched squeaks and everything in between. A properly designed hearing aid filters the whole spectrum of sound into separate parts that are called frequency channels. A good way to think of it is like a rainbow.

By analysing sound in its smaller components, the hearing aid can adjust different parts of the sounds independently without affecting other parts. With more channels the hearing aid can be more selective in what it chooses to amplify.

The result is clearer sound in noise and less distortion in some environments.

Of course, having 64 channels doesn't mean that the device is twice as good as having 32 channels. And the quality of a hearing aid doesn't depend just on the number of channels – the quality of the underlying amplification technology is paramount, as is the ease of use.

The price

Let's get a possible negative perception out of the way up front: at $1725.00 each, the SIE-64s are $500 more expensive than the $1250.00 SIE-32s. And they're an even more significant $735.00 more expensive than the LOFs, which sell for $990.00 each. Obviously, for a pair you double the prices.

Those prices might look expensive – but mosey into any audiologist (particularly those with shop fronts in shopping centres) and discuss digital hearing aids and you'll find that prices start at a few thousand each and go up – way up – from there.

As I mentioned in the earlier review, I was told when I first had my hearing tested that I'd have to spend at least $10,000 each to get a reasonable digital hearing aid: "anything under that is not much good". Well, not from them, anyway.

So $1750 each compares very well with what is currently offered on the "professional" market (as long as you are comparing apples with apples). If your budget can't quite stretch that far the LOFs at $990 each are still a perfectly viable alternative.

All models come with a "starter kit" containing ear tips (a variety pack with various sizes), a carry case, a box of 60 batteries, wax cleaning tools, a drying jar and instructions. Most of the ear tips are open type but two are occluding, which means they seal the ear canal to stop extraneous sounds getting in and sound produced by the in-ear speakers from getting out!

By the way, don't be tempted (conned?) into buying some cheapie out of China – with all the claims in the world – for perhaps fifty bucks or so. They're all over ebay.

I know someone who was tempted and their purchase lasted less than a day before going into the bin! The difference between a properly designed hearing aid and a cheapie really is the proverbial chalk and cheese.

Or is it simply that one works and one doesn't!

Controls

On-board controls are minimal but also different between models: all three have an automatic volume control but the 64s have an up/down button, where the 32s have a digital dial and the LOFs an analog dial.

Program selection on the 64s is via an up-down button, the 32s use a magnetic wand while the LOFs use both a magnetic wand and button.

Apart from the Telecoil option mentioned earlier, the only other "obvious" difference was in the prompts: the 64 has pre-programmed voice message while the others have a series of beeps, which you need to remember or refer to the instructions to interpret.

Programming

If you already have an audiogram and submit it with your order, Blamey&Saunders will supply your hearing aids pre-programmed to suit.

Alternatively (or if you want to experiment!) they have available PC software called "I Hear You", which suits all three models.

As well as enabling you to take total control of the aid programming, you can also send data to Blamey&Saunders support staff for advice if you need it.

On the SIE-64s, programs are "stepped through" by pushing the up-down button (no magnetic wand is required as is the case with the others).

Four programming "channels" are provided (on all three models); however a Telecoil option is normally pre-programmed into channel 2.

Digital technologies

As a final note, it's worth mentioning that Blamey&Saunders hearing aids offer, possibly uniquely, four different technologies in these Australian designed and developed hearing aids. First is the "ADRO" system, which stands for Advanced Dynamic Range Optimisation. This ensures that sound is always presented at a comfortable and audible level – not too loud, not too soft at every frequency.

Second is ADM – the automatic adaptive directional microphone, which increases the signal-to-noise ratio by reducing the loudness of background noise from some directions.

Third is AFC – adaptive feedback cancellation. This time-domain design is inherently resistant to distortion and provides up to 19dB of additional, stable gain.

Finally, they include ultra-low-delay sound processing. The shorter the delay (and by definition there must be some delay) the better the sound quality. Earlier hearing aids often produced reverberation and even echoes of the sound – most disconcerting! The SIE-64s have the shortest delay of any device in the industry, with no perceptible distortion or echo.

Are the SIE-64 worth the extra money?

I've been using both the old and the new hearing aids for about six weeks now, a few days with one type then I'd swap over to the others, just for a reasonable comparison. I've even gone without both for a few days here and there (and that was a real struggle!).

I noticed pretty well straight away that the SIE-64s are better than the LOFs. Even though I was very happy with those and, without knowing about the new models, would have remained more than satisfied.

But I *do* know – and I know that my hearing was better with the 64s. They have a crispness and clarity which I thought was pretty good in the LOFs but it is even more pronounced in the 64s. So yes, as far as I am concerned, they *are* worth the extra.

I didn't notice any particular difference in wearing them, despite the 64s being half the weight and quite a bit smaller. In all cases, they are quite unobtrusive behind the ears – most people will not know you are wearing hearing aids unless you tell them (especially if you have long hair!).

Conclusion

So once again, we take our hat off to an Australian company (pioneers in their field) which has again produced the goods with these hearing aids which compare so well with models *many* times the price. SC

For more information:
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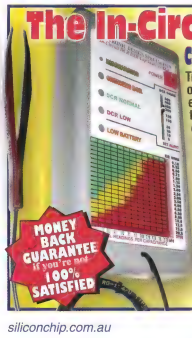

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SERVICEMAN'S LOG

PC power supplies: not worth fixing

Dave Thompson*

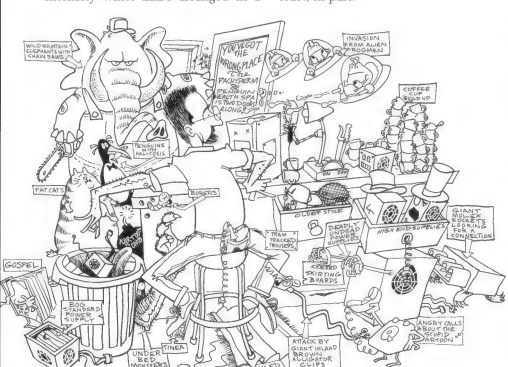
As with a lot of other electronic gear these days, PC power supplies are so cheap that they're not worth fixing. Instead, it's far easier to bin a faulty supply and bolt in a new one but there are a few things to watch out for.

EXPERIENCED SERVICEMEN know that many common problems in electronic gear are due to power supply faults. Indeed, checking out the power supply is often the first step in the troubleshooting process and this usually involves measuring the supply rails at various points in the circuit.

And yet power supplies are often neglected or taken for granted. That's probably because many supplies these days are modular or in some cases, not even an integral part of the device.

For example, I recently purchased an illuminated magnifying desk-lamp that utilises a dozen or so high-intensity white LEDs arranged in a ring around the magnifying glass. It obviously needs some sort of power source to light the LEDs but instead of having a heavy-duty mains cord and a bulky in-built power supply, it uses a separate plugpack supply. This feeds power to the lamp via a less-cumbersome lightweight cable and a small connector.

The external supply not only greatly simplifies the lamp's manufacture but also means that the housing can be made physically smaller, so that it takes up less space on the desk. That in turn reduces the cost, a benefit that's normally passed on to the end-user – at least, in part.



IT'S FAR EASIER TO BIN A FAULTY POWER SUPPLY BUT THERE ARE A FEW THINGS TO WATCH FOR...

In some devices however, an internal power supply is preferable. As a result, many different power supply modules are available to suit such equipment. Should the supply fail, it's dead easy to swap it out for a new module.

Computer power supplies are a classic example of modular design. And although some of the more high-end (and expensive) supplies are coveted by those into activities like hard-core gaming, 3D rendering and other high-performance areas, the bog-standard computer power supply has remained pretty much the same over the years.

Both AT (older style) and the more modern ATX units are switchmode supplies capable of delivering some serious power, in some cases more than 1000W although 400-500W is more the norm. A "new" BTX power supply standard was also introduced a few years ago but this has not yet been embraced by the majority of PC manufacturers and has made few inroads into the market.

Most PC supplies are stand-alone, modular units with a bunch of coloured flying leads passing through a grommet or strain-relief system at the back of the case. These leads run to various connectors which plug into the motherboard and disk drives. The standard voltage rails available are 3.3V, 5V and 12V, with some dual rails (positive and negative) also sometimes used for various functions.

A 20-pin or 24-pin Molex-style connector is typically included, along with an auxiliary 4-pin or 8-pin 12V supply to power the motherboard. There are also several different connectors for powering IDE or SATA and optical drives and sometimes (depending on the supply) even more leads for powering auxiliaries such as accelerated graphics cards.

Most power supplies sport at least one cooling fan, while some supplies will have two. Higher-end supplies tend to have fancier fans and a neat arrangement of Molex-style sockets

built into the case instead of a jumble of flying leads, allowing end-users to connect only those power leads they need. This results in a neater appearance, with far less "rat's nesting" inside the case.

These standalone PC supplies are fixed in place using just four screws, so they are ideally suited for repair or replacement by the DIY technician. For professionals in the trade, changing a power supply is one of those "gravy" jobs that usually requires little technical skill and takes very little time.

However, as with anything, there are traps for younger players. The first is determining whether or not the old power supply is the real culprit if a system appears dead in the water.

Dead power supply symptoms are usually pretty obvious, with absolutely nothing happening when the computer's power button is pressed, ie, no lights, no whirring fans and no other indications of life. In some cases though, you might see the CPU fan and the power supply fan(s) "kick" slightly when the button is pressed but this is not an indicator that things are all OK with the power supply.

The first step is to make sure that everything is plugged in correctly and that the wall switch is on. After that, the only way to really be sure that the power supply is the problem is to swap the unit out and see what happens.

And therein lies a quandary; if something has shorted out or caused the old supply to blow or otherwise fail, there is always a chance that when you plug in a shiny new one, it too will quickly bite the dust. That's why I always have a good stock of old surplus supplies that can, if necessary, be sacrificed to the computer gods without too many tears.

The DIY repair guy usually doesn't have that luxury and while it is a relatively rare situation that something inside the machine has caused the power supply to fail, it's always a slight possibility. That said, in 15 years of working on computers (literally thousands of them), I have only once plugged in a replacement supply and had it blow.

So the odds are that it will never happen to you but it is something to be aware of. If possible, an old, known-working supply should always be used to test the PC before a new supply is fitted.

Power supply testers

Another thing worth mentioning is the availability of a variety of power supply testers. These are usually housed in a small plastic case and feature all the standard sockets used in typical computers plus rows of LEDs to indicate if the correct voltages are present.

In use, the power supply is simply plugged into the main 20 or 24-pin socket on the tester and the LED indicators checked. If there is life, the remaining supply cables are then plugged in one by one and their respective LED indicators checked.

It all sounds easy (and it is) but these testers are not definitive. I found this out very early on when customers would come in and say that they (or a mate) had already tested the power supply using one of these devices and it had indicated that everything was OK. But although it might have tested OK, swapping it out for a new one subsequently fixed the problem, so their supply was probably failing under load.

On a personal note, I have seen many power supplies test OK when plugged into my own comprehensive tester but then fail to power up a computer when pressed into service. Again, this hasn't occurred often but it has happened enough to make me not take any power supply tester's results as gospel.

Another possibility is for one rail or output line to fail while the rest work as expected. However, my experience is that if a 3.3V, 5V or 12V rail is missing, all the others usually are as well.

Of course, the reality is that it

Items Covered This Month

- PC power supplies
- Samsung J845 front-loading washing machine
- Oven controller repair
- A hum problem with a twist
- Faulty GPS/fishfinder

**Dave Thompson, runs PC Anytime in Christchurch, NZ.*

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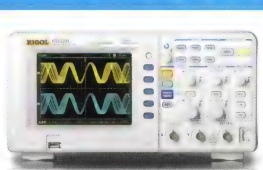

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doesn't really matter what has caused a supply to stop working. A faulty power supply is no good to anyone and simply needs to be replaced. The good news is they are inexpensive and almost anyone can do the job, which also means that repairing them is not usually economically feasible.

I had a chap visit the workshop a few years ago and he was offering repairs to power supplies, as well as reconditioned units. However, the repairs worked out to about the same as a new supply and while he offered a warranty, it just didn't make sense to me to be selling reconditioned supplies when new ones were so cheap and readily available. I suppose that if you had a very high-end supply and it was cheaper to repair than replace, it may be worth it. However, I have never been in that position.

I have to admit that in the early days, I thought I could economise by fixing computer power supplies myself. However, despite several attempts, I failed to get even one dead supply working, so I quickly gave up on the idea. My limited knowledge of PC power supply design was probably the main reason for this. And as previously stated, the cost of new supplies makes it uneconomical to go down that road.

What's more, these are complex, high-powered devices and a mistake could prove to be not only spectacular but also physically dangerous. So, like everyone else, I decided to just swap a power supply out for a new one when needed.

Quake faults

On another note, you'd think that most of the "dead" machines I've seen as a result of the Christchurch earthquakes would have been physically damaged – possibly by either falling off a desk or by having something heavy fall on them. But strangely, this is not the case. While I did see some physically-damaged machines, most were "killed" by mains power events.

The bigger quakes tended to knock the mains power off-line with several savage cuts and surges – rather like someone rapidly flicking a mains switch on and off half a dozen times. And that's a real problem for sensitive electronic equipment such as computers, TVs and games consoles.

Many of the smaller quakes also caused power events, although these were less "serious" and often resulted in brown-outs which can play havoc with electronic gear. It's also worth noting that the mains power in some areas is still not up to scratch and this is especially noticeable during the winter months when demand is high. It's not unusual to see the lights dim and the TV flicker as the mains power sags and then recovers.

A "grubby" mains supply is tough on computers and that's why I've replaced an inordinate number of power supplies and power-damaged motherboards over the last couple of years. The number is certainly far more than in the years before the quakes.

Noisy fans

By far the most common PC power supply complaint is a noisy fan and that's often easy to fix.

Most power supplies have a fan which sucks air in through the case and expels it out the back. Unfortunately, computers attract dust like crazy and fans sucking in dust-filled air for cooling are one of the main problems. This dust also builds up on fan blades and bearings, which often results in a grumbling fan.

The first thing to do is to disconnect the mains plug, then blow out the supply with dry, low-pressure compressed air. A paintbrush or similar can then be used to clean those parts of the fan blades you can reach and this can then be followed up with another blast of compressed air.

A bottle of all-purpose oil with a blunted hypodermic needle pushed onto the nozzle is the ideal tool to get oil to the fan bearings. It's just a matter of pushing the needle through the dust cover over the fan bearing and then applying the oil. A good lube job often keeps fans going for another year or two and it's cheaper than replacing the whole supply just for a noisy fan.

Don't attempt to pull the supply apart and replace the fan if that doesn't do the trick though. The electrolytics inside these supplies can retain a nasty high-voltage charge long after the supply has been turned off, so they are a real trap for the inexperienced. It's far better, easier and usually cheaper to simply replace the entire supply.

Samsung front-loader

By using a bit of common sense, it's often possible to fix faults on equipment that are normally outside our field of expertise. D. S. of Maryborough, Qld recently did a friend a favour and turned into an appliance repairman. Here's his story . . .

Recently, I took on a job I wouldn't normally take on. I don't normally do washing machine repairs but this was a favour for a friend and besides, I needed to get out of the house for a while and take a break from the kids who were home during the school holidays.

The machine in question was a front-loading Samsung J845 which, I was told several times, had given years of faithful service – at least until now. And the problem? "It doesn't turn on!"

A quick check with a multimeter confirmed that the mains socket was supplying 230VAC. That meant I would have to delve into the machine itself so I removed the lid by undoing a few screws and began checking the input to the EMI filter.

The cables surrounding this filter (it looks a bit like a start capacitor) were slightly stained with what appeared to be soot. This initially led me to think that the filter had failed but when I checked it out electrically, it was working perfectly.

Having cleared the EMI filter, I then decided to check the input to the power board. Unfortunately though, this is difficult to do, as it's encased

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in resin. In the end, I settled for a visual inspection and this revealed no obviously damaged components or burnt resin. It was obviously receiving power, as were the water pump and the inlet valves which are switched via FETs on the power board itself.

Despite this, the machine wasn't turning on or lighting any of the indicator lights. That meant that there was probably a logic fault on the control board.

Removing further screws allowed me to separate the control assembly from the front fascia and gain access to the control board. This board is mounted in a plastic enclosure but is easily removed provided care is taken not to damage the ribbon cables.

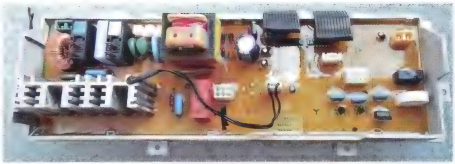
No visual damage was evident so I began checking voltages at various points on this board. Unfortunately, I didn't have a schematic so I had to use a certain amount of guesswork and logic here. Anyway, these checks revealed several low DC voltages which seemed about right. In particular, there was +5V running to the various ICs, LEDs and switching transistors and 3.5V to the main controller chip. So, the standby voltage was present but that was all.

The main power switch pulls a line from the CPU low which in turn should wake things up – but it didn't. However, the POST (power on self test) that the machine undertakes when mains power is first applied was successful so I doubted that the CPU was faulty.

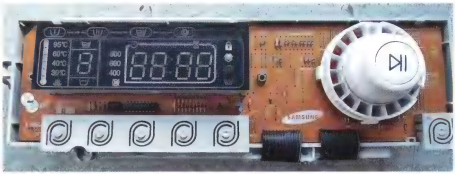
My next step was to check the various inputs and outputs, including the water level sensor, the door lock sensor and the level sensor (the machine has a sensor to ensure it's level before use). These checks found nothing amiss, so I began checking the switches on the control board itself.

These switches are for wash time, half load, delayed start, spin speed, temperature and pre-wash. In operation, they all pull a signal line from the CPU low, as does the rotary encoder for program selection. A few quick checks revealed that all these switches were working correctly except for the pre-wash switch. The line from this switch was already low!

So did this switch work in the opposite sense to the others, ie, by normally holding the CPU line low and allowing it to go high when pressed? I removed the switch from the board and guess what – it didn't change state when pressed. As a result, I decided to replace the switch.



The power board from the Samsung J845 washing machine is coated with resin to make it waterproof but it does make servicing more difficult.



The fault in the Samsung was on the control board and involved one of the pushbutton switches (lower left) which had gone permanently short circuit.

All these switches are miniature tactile NO (normally open) types with 1.5mm-high button actuators and with two through-hole leads. All I had on hand were 4-lead types but I modified one of these to suit and re-drilled the PCB to suit the slightly larger pin spacing.

That done, I reassembled the boards into their respective plastic covers and reconnected the wiring harness. The machine then sprang into life as soon as the power button was pressed! It was then just a matter of replacing the top cover on the machine and sliding it back into its niche.

This entire episode took me all of an hour and saved the owner several hundred dollars. If he had called in a specialist appliance serviceman, the control board would probably have been replaced, all for a 95-cent a tactile switch. After all, time is money and a serviceman cannot afford to spend time diagnosing faults on circuit boards to component level.

Oven controller repair

I. C. of Coolgardie, NSW recently solved two unrelated problems in an infrared oven controller. Here it is in his own words . . .

The miscreant is this story was a 3-zone infrared belt furnace used for firing thick-film microcircuits. The physical layout is basically a 2-metre-long, narrow box, containing the belt, heating elements and thermal insulation, with a shorter box above this containing the electric power control devices and the instrumentation.

Initially, we had a lot of trouble with the mains wiring when it came to installing it. That's because the design was for US-style 230VAC phase-to-phase mains but the furnace was wired for Australian 230VAC phase to neutral mains and there were some strange cultural differences, like fuses wired into earth circuits. Those problems eventually solved, we began attacking further problems in the control circuits.

There were three PID temperature controllers, one for each zone, and the operating temperature was around 850°C, which was controlled to about 2°C. However, the controller for zone 3, the zone furthest inside the furnace, had a nasty habit of shutting down after a period of operation.

My colleague J. C. and I stood puzzling over the problem when she suddenly asked me what happened to the air being forced into the control cabinet by the two "muffin-style" fans mounted on the bottom. Suitably alerted, I looked more closely at the construction of the cabinet and realised that there was no exit point for the air, beyond incidental leaks.

A Hum Problem With A Twist

This story comes from P. B. of Beacon Hill, NSW and concerns an annoying hum problem when he hooked his new TV up to the stereo amplifier. Here's how he solved it . . .

Some time ago, I decided to replace my old CRT TV with a new LED-backlit LCD model. However, the speakers in modern "slim" TVs are so bad that I decided to feed the sound from the new TV into my stereo system, to improve the sound quality.

The amplifier is an old Technics SA-104, so old that it has a grounded chassis but not too old to give decent performance. However, when I was hooking it up, I was shocked (pun intended) when I felt a significant tingle between the RCA ground from the TV and the amplifier's case. In fact, the measured potential between the two grounds was about 120VAC.

Basically, this voltage exists between the outer case of any double-insulated equipment with a switch-mode supply and mains earth (in this case, the chassis of the earthed amplifier). It's caused by capacitive coupling effects and resultant leakage currents in the switchmode supply. Once the grounds between the two pieces of equipment have been connected, the problem disappears.

(Editor's note: this subject was covered in detail in the July 2006 issue of Silicon Chip, in an article entitled "Stop Those Zaps From Double-Insulated Equipment!").

After connecting everything up, I found I had an intermittent right channel and eventually narrowed the fault down to the main speaker terminal on the amplifier. I disassembled the amplifier and found a cracked solder joint where the terminal connects to the PCB. Resoldering it fixed the problem.

With everything subsequently reassembled and connected, it all seemed to work except for one annoying problem – there was an unacceptable background noise, particularly at mid to high volume. This was a 50Hz hum with hash on top and my first thought was that this was probably due to a "ground loop".

By disconnecting different pieces of equipment, I removed all possible ground loops but the noise remained until I removed the last RCA input. This was the TV and I already knew it generated a small ground current from its "tingle" voltage. So maybe the amplifier PCB wasn't properly grounded?

I disassembled the amplifier yet again and checked the grounding. The PCB grounding to the chassis relied on three sheet-metal screwed joints in series. As a result, I found a suitable ground point on the PCB and connected it directly to the chassis ground terminal to bypass these joints

That didn't fix the problem so I looked more closely at the PCB itself. First, I used a multimeter to check all the ground points and this indicated that they were all "solidly" connected. Then one of those serendipitous things happened, for which I cannot take any real credit. With the amplifier powered on, I again checked for continuity between the RCA terminal ground and case. The continuity beeper "burbled" with an obvious 50Hz signal superimposed on the continuity sound.

When I subsequently shorted an RCA input ground to the case, the noise disappeared completely. At that stage, I knew I was close to homing in on the errant noise signal.

A closer look at how the RCA input shields were grounded revealed about 10Ω of resistance to the PCB ground. Evidently, the "tingle" current was developing enough voltage across this resistance to add hum and hash to the signal.

I started to look very closely at the PCB tracks and components to see if this 10Ω of resistance was intentional or accidental. On tracing the track from the RCA ground to the PCB ground, I was astounded to find that a 1mm piece of the track was missing. And no, it hadn't been removed – it had never been there in the first place. The void was covered with green solder resist and was clearly a manufacturing fault.

Soldering a link across this gap completely stopped the hum. But why had I never had a problem with this noise before? In this case, it appears that the TV put more "tingle" current into the earth terminal than any other device, showing up the residual fault in the amplifier.

Now who was it that said servicing is easy because you know it once worked before?

This particular style of fan is very sensitive to back-pressure and although capable of moving a large volume of air, is not able to do so in the presence of more than trivial back-pressure. The top of the control cabinet was closed off by a formed steel panel, which I lifted and propped open to provide an air exit. We then defeated the microswitch safety cut-out, applied power and confirmed that the temperature controller now operated without interruption.

Having confirmed the nature of the problem, we mounted a third "Muffin" style fan on the top of the cabinet. This provided an exhaust from the cabinet and as a bonus, further improved the cooling.

That wasn't the end of the problems though. The factory's final QA sheet showed that the furnace's belt speed control had been satisfactorily exercised over its full range, about 5-150cm per minute as I recall, but something wasn't quite right. The belt speed appeared to vary with the control but the LED speed display remained restricted and subsequent measurements confirmed my observations.

I immediately had a bit of a probe around the circuit using a scope and soon found that the supply line to the belt-speed controller was heavily infested with high-frequency ripple. And that was despite the supply being derived from a 3-terminal regulator.

Further inspection revealed that the 3-terminal regulator had originally been mounted on a PCB, close to the appropriate bypass/stability capacitors. However, it appears that the high temperature inside the cabinet had forced a rework of the mechanical layout because the regulator had been moved off-board to a much larger

heatsink. Unfortunately, the bypass capacitors had not made the same move, so the regulator was oscillating furiously and the digital readout was displaying whatever it made of the ripple on its supply line.

Moving the bypass capacitors close to the regulator's pins solved the ripple problem and the oven then worked as expected, with the full range of speed variation.

Faulty fishfinder

Something was definitely fishy about his son's GPS/fishfinder not working but tracking down the fault proved to be quite straightforward for B. G. of St Helens, Tasmania. Here's what happened . . .

Recently, I had a call from my son informing me that his GPS/fishfinder had failed just prior to a fishing trip. I immediately asked if the battery was OK and would it crank the motor? The answer was yes, so it wasn't the battery and there was nothing for it but to make the trip to town, some two hours away.

When I eventually set eyes on the unit, I unplugged the power and antenna and found 12V at the plug but ominously there was a rattle from inside the fishfinder. On opening the back, out fell an SMD electrolytic capacitor. It appeared that a cable loom had pushed this off the board during assembly. Fortunately, we had a 12V soldering iron handy and soon managed to refit the electro in place.

It was too much to hope that this was the problem (perhaps by causing a short) and my pessimism was well placed. The GPS/fishfinder was still a "no-go".

A look under the console revealed that the switching and wiring were all in order, so it was time to get serious. The back was removed again, the power plug installed and the supply voltage measured on the PCB after the power switch. As this was a complex device, all I could realistically do was carry out a few basic checks like this.

On this occasion, luck was with us because there was only 7V on the PCB and this subsequently varied each time the power switch was operated.

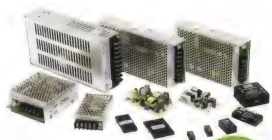
It was time to take a closer look at the wiring under the console. A series of blade fuses fed the various switches for the radio, GPS, lights etc. These blade fuses all looked and tested fine

FAULTY FISHFINDER

but then I noticed a plastic in-line fuseholder that was also in series with the GPS. On opening this up, the amount of corrosion present on the fuse and ferrules was unbelievable.

Using this type of fuseholder in a marine environment was just asking for trouble so we duly bypassed it. After all, the equipment was already protected by a blade fuse, so the in-line fuse was unnecessary. This restored the GPS/fishfinder to normal operation.

So Mr Ohm had thrown a spanner into the works yet again. SC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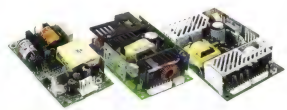

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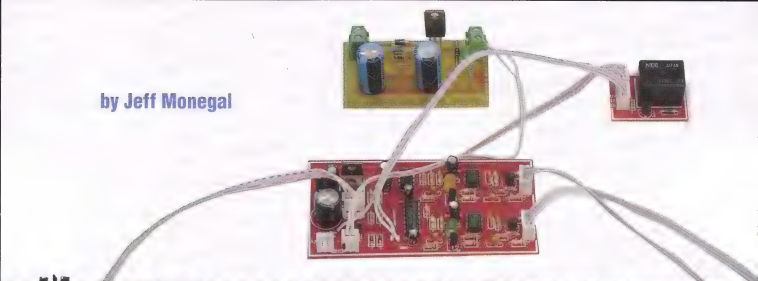


Automatic Poi
for your Model

This Automatic Points Controller can be used by itself on a model railway layout or in conjunction with the Automatic Reverse Loop Controller that was published in the October 2012 issue of SILICON CHIP.

That project automated the process of switching track polarity in a reversing loop but the points themselves still had to be operated manually. The project presented here takes care of that problem.

(Note that both projects are only suitable for reverse loops that use a single set of points. It will not work with reversing track systems that use more than one set of points, such as a 'WYE' network.)

So as well as automating the points used in a reverse loop, this project can be used wherever points could benefit from automatic control.

One example is a set of points used on a main line that branches to a siding. During layout operation a train may be shunted into this siding but the driver has forgotten to switch the points back, to allow the fast passenger train that is due soon, to pass the points without derailing.

Using this project to control the siding points, the approaching passenger train will automatically align the points so that derailments are prevented.

Let's now have a look at the circuit in Fig.1 (overleaf).

The IR sensors used to detect the approaching trains are made by Vishay, type TCRT5000. These contain an infrared LED and infrared phototransistor and they a designed as a reflective sensor, ie, the LED emits infrared and it needs to be reflected back to the phototransistor for the sensor to work. In use, the sensor is installed between the track sleepers and infrared is continuously emitted from the LED.

The controller relies on these tiny infrared sensors which fit between the track sleepers and detect when a train is passing over them.

An IR signal is constantly transmitted up between the sleepers of the track.

As a train covers the IR emitter, a small amount of the IR energy is reflected back to be received by the IR phototransistor which is physically located near the IR emitter.

The reason for choosing an IR sensor is that they operate just as well in normal ambient lighting conditions as they do in total darkness.

How it works

The two IR sensors operate in the same way. The heart of the circuit is an LM567 tone decoder which is used in an unconventional way.

Normally, the LM567 is used in circuits which sense the presence of a signal within a designated passband. If the signal is present, the output at pin 8 goes low; when it is absent or

This project uses two IR sensors to detect an approaching train and then automatically switch a set of points to suit the track on which the train is travelling. This avoids the possibility of inadvertent derailments by the operator. It uses four cheap ICs, two Mosfets and it controls a standard twin-coil snap-action points motor.

ıts Controller
Railway Layout

not within the passband, the signal at pin 8 is high.

The LM567 can be regarded as a specialised phase lock loop (PLL). A typical PLL has a voltage-controlled oscillator (VCO), a phase detector and loop filter and it is used in a radio receiver to keep the receiver locked onto an incoming carrier.

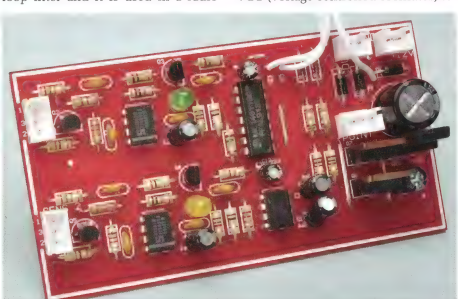
By contrast, the LM567 has a VCO and two phase detectors (I & Q) and a loop filter but we use in a different way.

We are using the chip's on board VCO (voltage controlled oscillator) to produce the signal which drives the infrared LED and components connected between pins 5, 6 & 0V of IC1 set its frequency to around 1kHz.

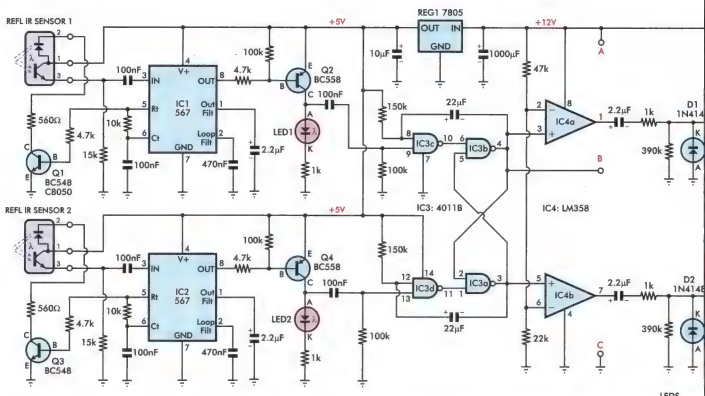
If the emitted IR signal is reflected back to the phototransistor (as when a loco is passing overhead) in the Vishay sensor, the resulting signal is fed from the sensor's pin 3 to pin 3 of IC1 via a 100pF capacitor. The result is that the output pin 8 goes low.

At other times, when no loco is on the track, no IR signal is reflected back to the phototransistor and the signal at pin 8 is high. Hence, when a loco is present above the sensor, pin 8 of IC1 goes low and this turns on PNP transistor Q2 to light LED1.

At the same time, the positive-going signal from the collector of Q2 is coupled to NAND gate IC3c via a 100nF capacitor. Pin in 10 of IC3 now goes



(Left): the main PCB for the Automatic Points Controller takes the output from the infrared sensors and drives the point motors to set the points according to the track in use.



SC 2013 MODEL RAILWAY AUTO POINTS CONTROL

low and this toggles the RS flipflop comprising gates IC3a and b. Pin 4 now goes high and pin 3 goes low.

The low from pin 3 is coupled around to pin12 via a 22µF capacitor. This capacitor then charges via a 150kΩ resistor taking around 1.5 seconds to reach a level that will allow IC3d to be triggered by a high coming in on pin 13, from the other sensor circuit.

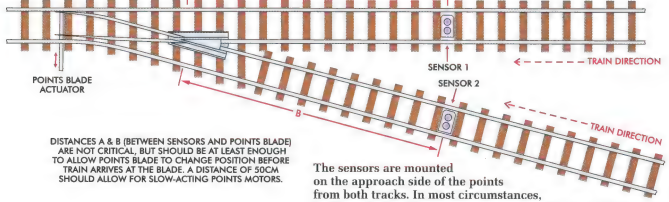
When a trigger pulse comes in from either sensor the associated 22µF/150kΩ circuits stop the flipflop from being toggled back again within this 1.5-second period. This ensures that when a sensor toggles the points it cannot be toggled back again by a signal from the other sensor until the capacitor discharge unit (CDU) for the points drive circuit has charged up again.

It also prevents the points swapping back and forth in the event that both sensors are detecting trains.

During actual layout operation, the situation where two trains are approaching the same set of points, should not be allowed to occur; a serious crash could result.

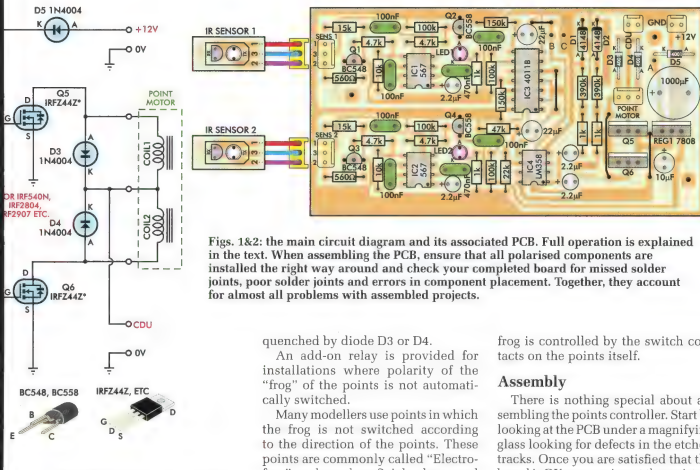
The outputs of the flipflop are fed to the non-inverting (+) inputs of two op amps, IC4a & IC4b. These op amps are there solely to increase the 5V signal from the sensor circuits to a level sufficient to reliably turn on either of the two Mosfets, Q5 & Q6.

The outputs of each op amp are coupled to the Mosfet gates via 2.2µF capacitors. In conjunction with the 390kΩ resistors, this results in a gate pulse of around two seconds. Once the 2.2µF capacitors have charged, the Mosfets gate are pulled low via the 390kΩ resistors.



DISTANCES A & B (BETWEEN SENSORS AND POINTS BLADE) ARE NOT CRITICAL, BUT SHOULD BE AT LEAST ENOUGH TO ALLOW POINTS BLADE TO CHANGE POSITION BEFORE TRAIN ARRIVES AT THE BLADE. A DISTANCE OF 50CM SHOULD ALLOW FOR SLOW-ACTING POINTS MOTORS.

The sensors are mounted on the approach side of the points from both tracks. In most circumstances, the distance from the sensors to the points is not critical.



Figs. 1&2: the main circuit diagram and its associated PCB. Full operation is explained in the text. When assembling the PCB, ensure that all polarised components are installed the right way around and check your completed board for missed solder joints, poor solder joints and errors in component placement. Together, they account for almost all problems with assembled projects.

Using series capacitors ensures that the Mosfets only remain switched on long enough to ensure the points have changed position.

Next time the flipflop toggles either one of the op-amp outputs must go low. Because the associated 2.2µF capacitor is charged to the positive rail, the voltage on the capacitor's negative terminal will try to go below the 0V rail. Diodes D1 and D2 prevent this happening, to protect the Mosfet gates.

When either Mosfet turns off, there will be a positive spike voltage generated at the drain electrode and this is quenched by diode D3 or D4.

An add-on relay is provided for installations where polarity of the "frog" of the points is not automatically switched.

Many modellers use points in which the frog is not switched according to the direction of the points. These points are commonly called "Electrofrog" and are beneficial when used on layouts operated by DCC. In these conditions the frog polarity must be controlled by external means. See Fig.2.

The frog relay is controlled by an NPN transistor which is supplied base current from pin 4 of the flipflop. Each time pin 4 goes high the transistor switches on the relay. The SPST contacts of the relay are used to control the polarity of the frog.

When this system is used with points of the "INSULFROG" variety then this relay is unnecessary as the frog is controlled by the switch contacts on the points itself.

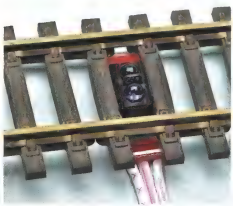
Assembly

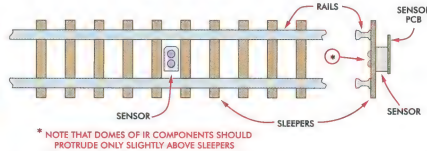
There is nothing special about assembling the points controller. Start by looking at the PCB under a magnifying glass looking for defects in the etched tracks. Once you are satisfied that the board is OK you can insert the resistors and diodes.

Also on the PCB are four wire links. These can be made from the wire off cuts from some resistors. IC sockets are recommended for IC1, IC2, IC3 and IC4. Solder these in next (or the chips themselves if you choose not to use sockets).

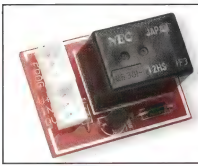
Next come the eight electrolytic capacitors and eight ceramic capacitors. The transistors and Mosfets can now be installed along with the regulator (in all cases, watch the polarity).

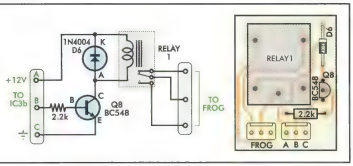
The final components are the 3-pin





Here's a close-up and diagram of how the sensors are mounted between the rail sleepers. You'll need to prise the sleepers apart a little: the sensor is a tight fit! When completed and tested, a drop of glue will hold it permanently in place.





At left is the Frog Switch Relay, with the simple circuit and PCB component layout show at right. The ponts "A, B & C" on the circuit diagram and overlay correspond to the same points on the main circuit diagram.

sockets for each of the two sensor leads and the points motor. The final two sockets are those for power input and the CDU in socket (two pins in both cases).

Although not mandatory to use plugs and sockets it makes things easy if you have to remove the PCB at any time!

Now you can assemble the two IR sensor PCBs. As only one component is used for each PCB assembly is not difficult but you must make sure that the components are oriented correctly.

The sensor has a bevelled end and a straight end; the bevelled end should face towards the three terminals on the PCB. The three wires connecting the sensor to the main PCB should be soldered underneath the board (ie, on the copper side) so that they are not seen when the sensor is installed under the track.

At this stage you should have no components left and no unused component holes in the PCBs. Take some time to go over your work. More than 70% of projects that don't work after being assembled can be put down to soldering faults. The next most common fault is polarised components being installed incorrectly.

These days faulty components are very rare so if your project does not work then don't straight-away claim you have a faulty component and replace all semiconductors. Chances are that your components will not be the problem.

Time to see if it will work

Start by making sure the sensors are facing straight up on the test bench and are not covered. At this stage do not connect any power supply to the CDU input terminals.

Use a current-limited power supply of about 12V, set to a current limit of about 500mA (this will ensure that no damage will result if a problem exists). Connect this supply to the power input terminals. The two LEDs will probably come on for a second or two, then the unit should settle down drawing less then 40mA.

Wave your hand about 50mm above each of the sensors. The LED associated with the sensor you are testing should come on and stay on for about two seconds after you remove your hand. Try this on both sensors. If the LEDs come on then both sensors are working.

Using a multimeter, CRO or logic probe look at the two flipflop output pins (3 and 4) on IC3. One should be high while the other is low.

Again cover the sensors one at a time. The flipflop pins should toggle. Pin 3 of the flipflop should go high when sensor 2 is triggered and pin 4 should go high when sensor 1 is triggered. If all this is happening then you can be fairly sure that the whole project is working OK.

Connect a power supply, preferably from the companion CDU unit that goes with this system, to the CDU input socket. If the CDU is not available then a DC supply of about 15V at 2A will do. The last step is to connect a twin-coil points motor to the points socket.

When you trigger the sensors the points motor should also swap positions. If all is OK then the system can be installed on your layout. If things have not gone as planned then do not slit your wrists just yet.

Fault-finding is simple

There is no microcontroller used in this project so fault-finding should be simple.

Finding the problem is simply a matter of elimination. If both LEDs are working when they should then at least half the project is OK. In this case looking at IC3 pin3 and 4 as previously described will tell if IC3 and its components are working or not. Using your multimeter check the following places. IC4 pins 2 and 6 should be at about 2.5V DC. IC4 pins 1 and 7 are the opamp outputs. One should be high (about 10V DC) and the other should be low. They should swap over when the sensors are triggered.

As previously stated, most likely the fault will be soldering related. Other components to check are diodes D1 and D2 in the Mosfet gate circuits. If these have be inserted backwards the drive signal to the Mosfets will not get through.

If the sensors are not working then you have two of them to compare voltages. It is highly unlikely that both will not work. If that is the case then most likely you have reversed the IR components.

Installation

A look at the diagrams and photos will show how the sensors are installed. The IR components are placed under the track with the domes of the components facing up between the sleepers.

The distance from the points back along the track to the sensor is not critical as long as the points have time to switch before the approaching train reaches it. 100mm would be about the minimum; we generally go for about double this.

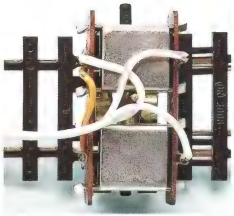
A small dob from a hot glue gun will make sure the sensors stay put.

Wave your hand above the sensors at an increasing distance. The sensors should not detect your hand at more than about 100mm.

Slow-motion points

However, at this stage you may want to plan ahead so that this project will work with servo and slow-motion points motors such as the tortoise motor.

If you intend to use these at a later date then you will need a sensor-to-points distance of at least 400 to 500mm. Using a slow motion motor gives a very realistic show of the points



A close-up view of the under-side of the points motors. Obviously, enough clearance needs to be allowed under the tracks in your layout to accommodate the bulk of these motors.

being switched.

Once you have the sensors installed, connect them to the main PCB then power it up. Run a loco or carriage over the sensors and make sure the LEDs indicate a successful detection. The sensors should detect all types of carriages and locos.

Once that is done you can complete the installation then sit back and enjoy another automated section of your layout.

Off-track sensors

During development of this system a sensor was installed inside a small electrical equipment box model that was then installed next to the track. As a train passed the electrical box the sensor reliably detected the passing of the train every time.

Although the sensors need to be disguised somehow this is another idea on how to reliably detect the passing of trains and has the advantage of not having to disguise the sensors that are installed under the track. SC

Parts List – Automatic Points Switching

1 main PCB measuring 105 x 55mm, coded JWM-0812
2 sensor PCBs measuring 17 x 8mm
3 3-pin PCB mount sockets
2 2-pin PCB mount sockets
3 8-pin IC sockets
1 14-pin IC socket

Semiconductors
2 LM567 tone decoders (IC1, IC2)
1 4011B quad Nand gate (IC3)
1 LM358 dual op amp (IC4)
2 Vishay TCRT5000 sensors (Sensor1,2)
2 BC548 NPN transistors (Q1, Q3)
2 BC558 PNP transistor (Q2, Q4)
2 IRFZ44 N-channel Mosfets [or equivalent] Q5, Q6)
2 1N4148 silicon signal diodes D1, D2)
3 1N4004 silicon power diodes (D3-D5)
2 5mm LEDs (red, green or yellow; LED1,LED2)
1 7805 3 terminal regulator

Capacitors
1 1000µF 25V electrolytic
2 22µF 25V electrolytic
1 10µF 25V electrolytic
4 2.2µF 25V electrolytic
2 470nF MKT (code 470n or 474)
6 100nF MKT (code 100n or 104)

Resistors (all 1/4 W carbon)

2 560Ω	4 1kΩ	4 4.7kΩ	2 10kΩ	2 15kΩ
1 22kΩ	1 47kΩ	4 100kΩ	2 150kΩ	2 390kΩ

Extra components required for the Frog Switching relay
1 PCB, 37mm 27mm
1 SPDT relay
1 IN4004 power diode
1 2.2kΩ resistor
1 BC548 or C8050 NPN transistor [or equivalent]

A complete kit of parts will be available from Oatley Electronics in Sydney. They can be contacted via their web site **www.oatleyelectronics.com** or by phoning them on (02) 9586 3564. Cost of the kit will be $25.00 plus $7.00 P&P.

For a short time you can purchase three kits for only $60.00 plus the same $7.00 P&P. The Frog switching add on circuit is $4.50

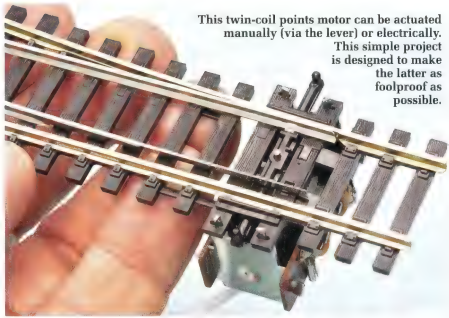
All enquires for this project should be directed to the designer, Jeff Monegal. He can be contacted via email only: **jeffmon@optusnet.com.au**
All emails will be replied to but please allow up to 48 hours for a reply.

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
☐	2	390kΩ	orange white yellow brown	orange white black orange brown
☐	2	150kΩ	brown green yellow brown	brown green black orange brown
☐	4	100kΩ	brown black yellow brown	brown black black orange brown
☐	1	47kΩ	yellow violet orange brown	yellow violet black red brown
☐	1	22kΩ	red red orange brown	red red black red brown
☐	2	15kΩ	brown green orange brown	brown green black red brown
☐	2	10kΩ	brown black orange brown	brown black black red brown
☐	4	4.7kΩ	yellow violet red brown	yellow violet black brown brown
☐	4	1kΩ	brown black red brown	brown black black brown brown
☐	2	560Ω	green blue brown brown	green blue black black brown

A Capacitor Discharge Unit for twin-coil points motors

Got a model railway? If it is not just a simple loop of track it is bound to have one, two or maybe dozens of sets of points. That means you need at least one Capacitor Discharge Unit (CDU) to power them. Most layouts can make do with just one CDU but this unit is so cheap you might want to have several.



This twin-coil points motor can be actuated manually (via the lever) or electrically. This simple project is designed to make the latter as foolproof as possible.

This Capacitor Discharge Unit, or CDU, is designed to drive the twin-coil snap-action points motors which are widely used on the majority of model railway layouts. These have the virtue of being cheap and easy to install under each set of points.

In action, if one coil (more correctly a solenoid) is energised, the points move across to favour one direction for the on-coming loco. If the other coil is energised, the points move across in the other direction.

Many rail enthusiasts energise these point motors by simply connecting the two coils to a 15V (or thereabouts) DC or AC supply via momentary contact pushbuttons. Briefly pushing one or other of the buttons operates the points. Simple.

The big disadvantage of that method is that if you press the button for too long or the button becomes jammed by something or someone leaning on, the respective coil will burn out.

Why? Because its resistance is only about 4.7Ω and it is wound with many turns of fine wire which simply cannot withstand the resultant dissipation of 40 watts or more for more than a second or two.

This is where the CDU comes in. It has a large capacitor which is charged from the 15V supply and then when one or other of the pushbuttons is pressed to energise one of the coils, it delivers a brief pulse to do the job and no damage can result if the pushbutton is pressed for longer than need be.

Now this CDU is being presented as a companion unit to the Automatic Points Controller in this issue but it can be used independently on any layout where points are being employed. The CDU is housed on a small PCB which can be located in a convenient position underneath the layout.

The circuit

The circuit is shown in Fig.1. It consists of a small NPN power transistor, two 2200µF 25V capacitors and not much else. It works like this. Whenever the circuit is connected to the 15V supply (which may be DC or AC) current flows via diode D1 to the collector of NPN transistor Q1. Q1 is biased on by the 1kΩ resistor between its base and collector.

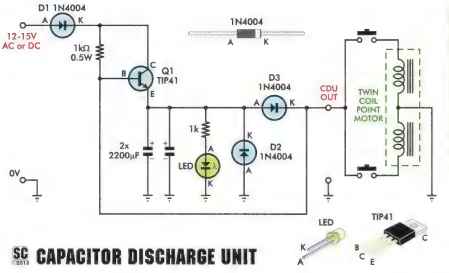
While ever Q1 is turned on, it acts to charge the two 2200µF capacitors. Once they are charged, the current through Q1 is quite low, due to the leakage of the capacitors themselves and the current through LED1 which indicates that the unit is active.

When one of the pushbuttons is pressed, the capacitor charge is dumped via diode D3 to the respective solenoid coil, energising the points motor in one direction or the other. D3 can easily withstand the brief pulse of current which is likely to be no more than 3A peak.

Diodes D2 & D3 act to suppress any back-EMF spikes which could possibly occur if the pushbuttons have contact bounce. Normally of course, the pulse current will die away quickly while you hold the button down for a second or two and no back EMF spike should be generated

If you keep the pushbutton depressed for longer, no damage can result since the base of Q1 is effectively

by Jeff Monegal



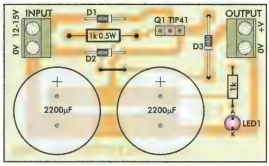


Fig.1 (left): the circuit diagram of the capacitor discharge unit shows it is basically a couple of capacitors and a switching transistor. Above (Fig.2) is PCB component overlay. It's simple enough – but watch component polarity!

SC 2013 CAPACITOR DISCHARGE UNIT

grounded via the respective solenoid coil, keeping Q1 turned off.

Once the pushbutton is released, Q1 is biassed on again via the 1kΩ base resistor and the capacitors are quickly recharged, ready for the next points operation.

Note that this CDU can power multiple sets of points. Each twin-coil points motor is wired to the CDU via a 3-way ribbon cable and two push-buttons.

PCB assembly

The CDU circuit components fit on a small PCB measuring 69 x 41mm. Assembly is straightforward but remember that all components, except the two resistors, are polarised and must be installed as shown on the overlay diagram in Fig.2.

After double checking that you have all components in the correct position and the correct way round you can apply a DC power supply of around 12-15V DC or AC to the power in terminals. The project is polarity-protected by diode D1 so if you connect the supply the wrong way nothing will happen. But if all is well, the LED will come on shortly after power is connected.

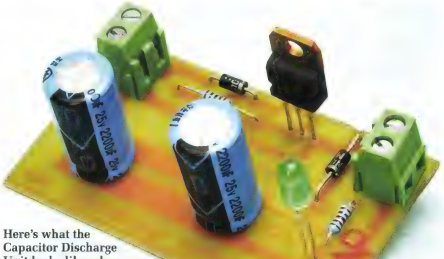
Using a twin-coil snap-action points motor and some hookup wire, join the centre terminal of the points motor to either output terminal.

Using another length of hookup wire with one end connected to the other output terminal touch the free end onto either of the other two terminals of the points motor. The motor should snap in one direction or the other.

At the same time the LED should go out but then come back on within a few seconds.

Try again with the other points motor terminal but this time leave the hookup wire connected. There should be very little (a few mA) load on the power supply.

Because the transistor is held off while ever the points motor is connected across the output, no current should flow. When the hookup wire is removed current should briefly flow again to charge up the capacitors, ready for the next application. SC



Here's what the Capacitor Discharge Unit looks like when assembled. The LED can be mounted remotely if it's more convenient – otherwise, it's a cinch to put together!

Parts List – Model Railway Capacitor Discharge Unit

1 PCB measuring 69 x 41mm
3 1N4004 power diodes
1 TIP41 NPN power transistor
1 5mm LED (any colour)
2 PCB-mount 2-way connectors
1 1kΩ 1/2W carbon resistor
1 1kΩ 1/4W carbon resistor
2 2200μF 25V electrolytic capacitors

A complete kit of parts will be available from Oatley Electronics in Sydney. They can be contacted via their web site **www.oatleyelectronics.com** or by phoning (02) 9586 3564.

Cost of the kit is $10 plus $7.00 P&P.

All enquires for this project should be directed to the designer, Jeff Monegal. He can be contacted via email only. (**jeffmon@optusnet.com.au**) All emails will be replied to but please allow up to 48 hours for a reply.

Control relays over the Internet with Arduino

Turning items on and off remotely via the internet has generally been a complex and expensive task due to the hardware and knowledge required. Not any more. Here we show how easy and inexpensive it can be to control four or more relays over the Internet using open-source Arduino-based hardware.

By JOHN BOXALL

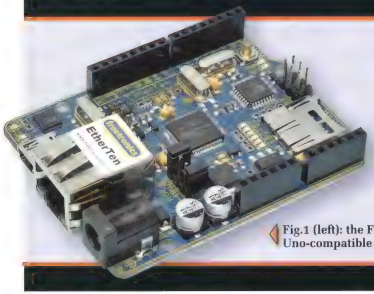


Fig.1 (left): the Freetronics EtherTen module is Arduino Uno-compatible and has an onboard Ethernet interface.

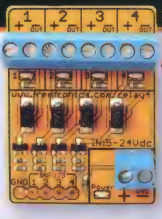


Fig.2: the Freetronics RELAY4 relay driver module. It interfaces directly to the EtherTen module & uses FETs to switch external relays.

IT'S NOT DIFFICULT to remotely control relays via the internet. In this article, we'll first look at the hardware required, then explain the software and network requirements. After that, we'll look at how commands are sent over the internet using a web browser to control the relays.

If you are unfamiliar with the Arduino environment, please refer to the article by Jonathan Oxer titled "Arduino – What's All The Fuss About?" in the January 2012 issue of SILICON CHIP or visit the homepage at **http://www.arduino.cc**

The hardware

The heart of the system is an Arduino Uno-style board with an Ethernet shield. In this case, we have used the Freetronics EtherTen board which conveniently combines both into a single unit, thereby saving space and money – see Fig.1.

The EtherTen board can control up to four relays via a Freetronics RELAY4 4-channel relay control module – see Fig.2. This module interfaces directly to the EtherTen Arduino board and uses FETs to switch the relay coils. It also includes reverse-connected power diodes to suppress back-EMF pulses when the relays are turned off.

Connecting the relay module to the Arduino board is very simple:

- *Input 1 to Arduino D2*
- *Input 2 to Arduino D3*
- *Input 3 to Arduino D5*
- *Input 4 to Arduino D6*
- *Logic GND to Arduino GND*

Note that when using an Ethernet-enabled Arduino board, digital pins 10-13 are used by the Ethernet interface and can't be used for other purposes. And in the case of the EtherTen board, digital pin 4 is used for the microSD card.

Note that, for this project, we don't use digital pin 8 either and we'll explain the reason for this shortly.

The next consideration is the power supply for the relay coils. Although there is a 5V power supply available from the Arduino board, it's unable to supply enough current to

drive most conventional relay coils. What's more, it cannot be used to power relays with 12V (or higher) coils. In either case, you will have to connect an external DC power supply with the required ratings to the RELAY4 board's power terminals (bottom-left of Fig.3).

On the other hand, if you can keep the current draw under 150mA and are using solid-state 5V relays (such as Jaycar SY4092) with very low switching currents, the on-board Arduino 5V supply will be enough.

With a 5V supply, the RELAY4 board itself draws around 13mA with all LEDs on. Add four relays drawing just 20mA each and you can comfortably power the lot from the Arduino. In that case, connect the positive pin from the RELAY4 power terminal to the Arduino +5V pin.

Testing

You can then test the connections to the RELAY4 board with a simple Arduino sketch (software program) that turns the outputs on and off – as indicated by the on-board RELAY4 LEDs. Once your hardware has been connected, enter and upload the following sketch using the Arduino IDE (Integrated Development Environment):

```
void setup()
{
  DDRD = B11111111; // set PORTD (digital 7~0) to outputs
}

void loop()
{
  PORTD = B01101100; // set D2, D3, D5, D6 HIGH
  delay(250);
  PORTD = B00000000; // set D2, D3, D5, D6 LOW
  delay(250);
}
```

At this stage, all four LEDs should be blinking on and off at 2Hz. If not, check the wiring between the two boards, including the GND line.

Software & network requirements

To control our Arduino over the Internet, we use a free online service called "Teleduino". It allows us to send commands to an Arduino board (via the Internet) using simple commands in the form of URLs similar to that used to refer to a web page.

You can find out more at the Teleduino website at **www.teleduino.org**

To identify an individual Arduino board to the Teleduino service, we use a unique key in the form of a long hexadecimal number. This key is issued by the Teleduino service and is inserted into the Arduino sketch and also into the commands issued to control the board.

To generate a key, simply go to **https://www.teleduino.org/tools/request-key** and complete the required fields. A short time later, your key will arrive via email – remember to store this for later retrieval. It will be a long string of characters, eg, 18F5F4749B058F952ABCDEF8534B2BBF.

The next step is to download and install the Teleduino Arduino library into the IDE. The latest library can be found at **https://www.teleduino.org/downloads/** Extract the library folder and copy it to the arduino-1.0.1/libraries folder in your IDE installation. If your IDE is running, you will need to restart it in order to use the library.

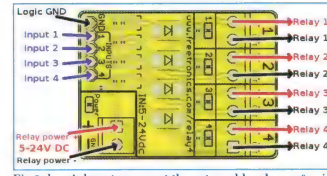


Fig.3: here's how to connect the external hardware & wire the power supply to the relay driver module.

You now have to prepare the Teleduino sketch for the Arduino board. This sketch connects the Arduino to the Teleduino server and also executes received commands via the service. The sketch is included with the library, so in the IDE select *File –> Examples –> Teleduino328 –> TeleduinoEthernetClientProxy*.

Before uploading the sketch, the unique Teleduino key needs to be inserted so the Arduino can identify itself to the service. To do this, go to **https://www.teleduino.org/tools/arduino-sketch-key**, enter your Teleduino key into the field and click "Generate Code". This will appear as an array in Arduino format as shown, for example, in Fig.4.

That done, scan through the Arduino sketch currently loaded in the IDE, locate the same byte variable (it should start on line 36) and replace the array full of zeros with your Teleduino key array – see Fig.5 (for example).

Once you have modified the sketch as above, upload it to your Arduino as normal. You should also save the sketch so you don't need to repeat the key-insertion process in the future. Note that if you are going to control multiple Arduino boards, you will need multiple Teleduino keys. Just remember to keep track of the key uploaded to each board.

The next step is to test that the Arduino is connecting to the Teleduino service by monitoring the connection status. This can be done using a LED indicator connected via a 560Ω resistor between the Arduino's D8 pin and GND, as shown in Fig.6.

Once the indicator LED is in place, connect the Arduino to your router via a network cable, apply power and watch the LED. After a few moments, the LED will start blinking to indicate the status of the connection to the Teleduino service.

```
byte key[] = { 0xAD, 0xAE, 0x57, 0x43,
               0x1F, 0xC9, 0xB9, 0xD1,
               0xCA, 0x90, 0xEF, 0x71,
               0xE6, 0x14, 0x45, 0xC0 };
```

Fig.4: a Teleduino key array in Arduino sketch format.

```
// The proxy server retrieves the key from the EEPR
byte key[] = { 0xAD, 0xAE, 0x57, 0x43,
               0x1F, 0xC9, 0xB9, 0xD1,
               0xCA, 0x90, 0xEF, 0x71,
               0xE6, 0x14, 0x45, 0xC0 };

// Other required variables
```

Fig.5: the Teleduino key array after insertion into the Arduino sketch.

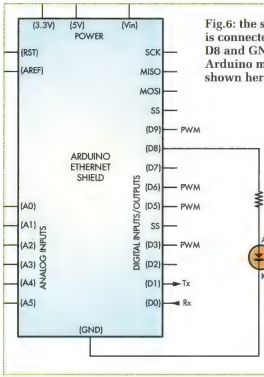


Fig.6: the status LED is connected between D8 and GND of the Arduino module as shown here.

At the time of writing, the following blink parameters are used:

- *1 blink: initialising*
- *2 blinks: starting network connection*
- *3 blinks: connecting to the Teleduino server*
- *4 blinks: authentication successful*
- *5 blinks: session already exists for supplied key*
- *6 blinks: invalid or unauthorised key*
- *10 blinks: connection dropped*

It is normal for the LED to work its way up from one to four blinks. After the connection and authentication is successful, the LED will then blink very briefly every 10 seconds or so. This signifies that all is well.

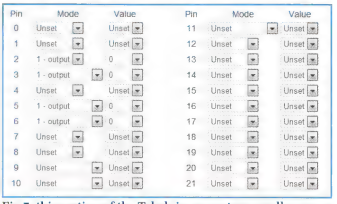
If your LED shows five blinks, just reset the Arduino board. If your LED shows six blinks, check your Teleduino key in the control sketch and re-upload it to the Arduino. And finally, if it blinks 10 times, the Internet connection has dropped out.

Although the above procedure may seem somewhat tedious, it is necessary to establish that everything is working correctly. Once you've done that, the status LED can be removed if desired but we suggest keeping it to aid troubleshooting if you strike problems in the future.

Default relay settings

The final step in setting up the Teleduino service is to decide what the default settings will be for each of the relays. These are the settings that the relays revert to when the Arduino board is turned on or reset, loses the Internet connection or the network cable is removed.

You can set the defaults after your Arduino has connected to Teleduino by browsing to **https://www.teleduino.org/tools/manage-presets** After entering your Teleduino key, a large selection of options will be displayed. Scroll down to the "Pins" section (see Fig.7) and change the



Pin	Mode	Value	Pin	Mode	Value
0	Unset	Unset	11	Unset	Unset
1	Unset	Unset	12	Unset	Unset
2	1 - output	0	13	Unset	Unset
3	1 - output	0	14	Unset	Unset
4	Unset	Unset	15	Unset	Unset
5	1 - output	0	16	Unset	Unset
6	1 - output	0	17	Unset	Unset
7	Unset	Unset	18	Unset	Unset
8	Unset	Unset	19	Unset	Unset
9	Unset	Unset	20	Unset	Unset
10	Unset	Unset	21	Unset	Unset

Fig.7: this section of the Teleduino presets page allows you to set the defaults for the Arduino's digital I/O pins.

mode of the Arduino pins you're using to OUTPUT. Then, depending on your needs, you can set the default relay status with the value parameter.

Controlling the RELAY4 module

To control the RELAY4 module, first launch your web browser (on a computer, smartphone or tablet). You can then control the Arduino's digital pins and thus the relays by going to **http://us01.proxy.teleduino.org/api/1.0/328.php?k=999999&r=setDigitalOutput&pin=X&output=Y**

There are three parameters you need to enter into this page. The first is your Teleduino key – simply replace 999999 with your key. The next is the Arduino digital pin to control – replace "X" with the pin number. And finally, to turn the pin on or off, replace Y with a "0" for off or a "1" for on.

For example, to turn on relay 1, you would use **http://us01.proxy.teleduino.org/api/1.0/328.php?k=999999&r=setDigitalOutput&pin=2&output=1**

To turn it off again, simply change the final "1" to "0".

You may find it convenient to bookmark the various URLs to make sending commands much easier. Furthermore, the use of URL-shortening services such as **http://bit.ly** can reduce their length to more manageable sizes.

By checking the status LEDs on the RELAY4 board, you can test the pin control without needing to wire up your entire project at the start. Also, when you send a command, the Teleduino server will return a message if the action has been successful or not. If the command worked, an output similar to the following will appear in the web page:

```
{"status":200,"message":"OK","response":{"result":1,"time":
0.2338559627533,"values":[]}}
```

Conversely, if it was not successful, you will see:

```
{"status":403,"message":"Key is offline or invalid.","response":[]}
```

This tells you that the Arduino has lost connection to the Teleduino servers.

Conclusion

Once you have run through the set-up procedure, controlling the relays remotely is quite simple. If you need to control more relays, either add another RELAY4 board or check out the Freetronics RELAY8 board.

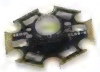
Finally, the Teleduino service allows web-based control of much more than your Arduino's digital outputs – refer to **http://www.teleduino.org** for more information. SC

MASSIVE LED CLEARANCE

P3-II STAR LED PCB

Bright 2w power LEDs mounted on a 20mm star pcb for easy connection.

Amber	AS2182
Blue	BS2182
Green	GS2182
Red	RS2182
Warm White	NS2182
Cool White	WS2182



EACH: $1.90 +GST

SEOUL

P4 POWER 4W LEDS

High Power LEDs in various colours up to 4w.

Blue	B42180
Green	G42180
Red	R42180
Warm White	N42180
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P4 STAR LED PCB

The same LEDs as above but ready mounted on a 20mm star PCB for easy connection.

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Less than half of last year's price.

F50360-STAR

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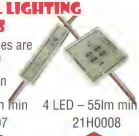

3 LED – 41lm min
21H0007

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4 LED – 55lm min
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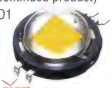
P7 POWER LED Final Stocks

SEOUL

As seen in Silicon Chip in Feb '11, these LEDs are very bright. Will deliver approximately 900lm of light when driven @2.8A. (Discontinued product)

Part No. W724C0-D1



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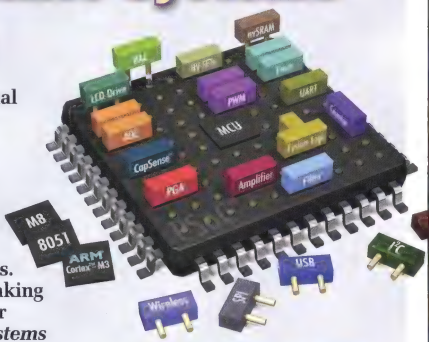
Programmable Systems on a Chip



Microcontrollers, Digital Signal Processors (DSPs) & Field Programmable Gate Arrays (FPGAs) have collectively revolutionised much of the electronics industry. There would be no such thing as a $300 100MHz Digital Signal Oscilloscope without these ICs. Cypress Semiconductor are taking the next logical step with their ingenious *Programmable Systems on a Chip*. Let's see what they have to offer.

By NICHOLAS VINEN

IF YOU'VE BEEN regularly reading our project articles, you will have seen just how many of them are built around a microcontroller (or a digital signal controller, which is a micro with DSP instructions). Clearly, those circuits are much simpler and more capable than we could have made them with just discrete componentry and the development time is often much shorter too.

And while SILICON CHIP has not published any circuits which use FPGAs or their poor cousins, Complex Programmable Logic Devices (CPLDs), they are used widely in commercial electronic gear when a microcontroller just isn't powerful enough. For example, crack open just about any DSO, from a budget $300 model up to those in the $10k+ price range, and you will likely find several FPGAs responsible for tasks such as interfacing with the high-speed ADCs, driving the LCD panel and so on.

FPGAs fill the gap between microcontrollers and custom logic ICs (also known as Application-Specific Integrated Circuits or ASICs). ASICs have a large development and set-up cost which only pays off when you're building tens of thousands of units or more. In many cases, a product can be brought to market more quickly and sometimes more cheaply by using configurable logic devices.

In fact, it's even possible to load one or more "soft cores" into an FPGA, yielding virtual microcontrollers which can be customised to suit the task at hand and surrounded by purpose-designed "glue" logic, all in one neat IC package. These soft cores can range from basic 8-bit jobs to full-on 64-bit multi-core microprocessors, given a sufficiently powerful FPGA. Some FPGAs also come with built-in microcontrollers since this is such a common need and it saves money and board space.

What about analog?

Of course, most microcontrollers and some FPGAs can interface to the analog world too, through analog-to-digital converters (ADCs), digital-to-analog converters (DACs) and other peripherals such as built-in comparators. For DSPs, interfacing with analog systems is effectively their raison d'etre and so they generally have dedicated interfaces to communicate with DACs and ADCs.

Yet it's still common to surround microcontrollers with a host of analog parts like op amps, filter stages, instrumentation amplifiers and so on, in order to effectively connect them to the "real world" of sensors, transducers, audio and so on. A fair few circuits are little more than a microcontroller and a series of analog ICs and associated passives; the microcontroller "does it all" from the digital perspective but usually only has fairly basic internal analog circuitry.

This is starting to change though. There are now Microchip PICs with built-in op amps, such as the PIC16F527, PIC16F1782 and most of the dsPIC33E/PIC24E series. There are also now some microcontrollers with fairly capable onboard DACs/ADCs (eg, up to 16-bit resolution). Clearly, microcontroller manufacturers are realising that with better analog interface circuitry, designers can save

space and money by not needing so many external interface chips.

Some micros now also contain some basic Configurable Logic Cells, such as the PIC16F150X. These are akin to small CPLDs and while they are only powerful enough to eliminate a few external discrete logic chips (eg, 74HCs), ultimately we hope to see this sort of feature grow to the point where you can "roll your own" digital interface circuitry within the microcontroller, rather than just settle with the modules that the manufacturer decides to provide.

Enter the PSoC

Cypress have taken both of these concepts – integrating additional analog circuitry and configurable logic – and run with them. They call the result a "Programmable System on a Chip" and that is quite an accurate description.

Essentially what you get is a single IC that contains a powerful ARM-based microcontroller, a boost regulator, a small LCD driver, capacitive touch-sense circuitry, programmable logic blocks, a USB transceiver, timers and PWM units, an accurate voltage reference, three high-speed ADCs, four DACs, four comparators, four op amps, configurable multi-function analog blocks, crystal oscillators and PLLs, debug support and the "glue" that you need to tie it all together into a working circuit.

Taking a step back, you can look at it slightly differently. Effectively, the PSoC is an ARM (Advanced RISC Machine) microcontroller with all the usual peripherals, teamed up with the 20-24 configurable logic blocks and all the various analog and analog/digital circuitry, with a series of multiplexers allowing the interconnections between the various units to be programmed in. So essentially you have most of the building blocks of a complete digital/analog circuit in a single package.

Analog circuitry

Because the analog circuitry is the most unusual part of the PSoC, let's have a look at what it comprises and what you could potentially do with it.

First, the voltage reference. It is necessary to have a good voltage reference if you are to use an ADC to accurately measure DC voltages (or for that matter, AC). Most microcontroller references

This PSoC3 is the first series of "Programmable Systems on a Chip" to use an ARM microcontroller core. The window in the background shows the graphical interface used to configure the chips.

are disappointing, with a typical accuracy (incorporating both factory trim error and temperature drift) of around ±5%. Compare this to the PSoC5's reference which is 1.024V ±0.1%!

As well as being used as the reference for the ADCs and DACs, this can also be routed to the other analog circuitry (eg, comparators and op amps) to set thresholds, provide a DC bias and so on.

Each PSoC5 chip has one differential delta-sigma ADC which can be set to have a resolution between eight bits and 20 bits, with a resolution/speed trade-off. For example, it can be set to 8-bit/384ksps, 12-bit/192ksps, 16-bit/48ksps and 20-bit/187ksps. With its good linearity, this makes it suitable for use with general analog signals, audio or for precise DC measurements.

There are two additional single-ended/differential successive approximation (SAR) ADCs, more typical of those found in microcontrollers but slightly more capable, being able to sample at the full 12 bits up to 1MHz.

The four built-in DACs have 8-bit resolution and can give either a voltage (1Msps) or current (8Msps, source or sink) output. They have programmable upper and lower voltage limits.

Op amps & comparators

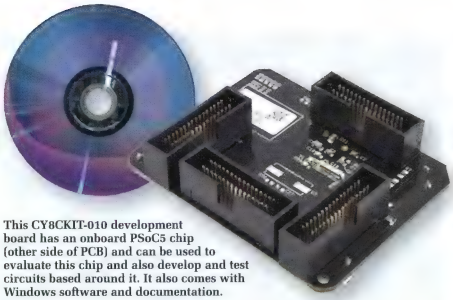
There are four comparators and the inputs of each are connected to one of the internal analog buses and thus may come from a GPIO pin, the output of an internal op amp, the voltage reference, one of the filter blocks, one of the DACs, configurable analog blocks (more on them later), etc. The outputs of the comparators are fed to a series of look-up tables (LUTs), allowing a pair of comparators to be used as a window comparator for example. The resulting state is then fed to the microcontroller and/or the configurable logic blocks.

The inputs for the four op amps can be connected either to a GPIO pin or to one of the internal analog buses. The outputs of all four drive a specific GPIO pin but these pins can also be connected to an internal analog bus, to feed the op amp output back into the system if necessary. Also, each op amp can be switched to buffer mode, therefore requiring only one input to be connected.

Configurable analog blocks

This is one of the more powerful parts of the system. There are four "switched capacitor/continuous time" (SC/CT) units which can be configured to operate in a number of ways. These include: op amp, unity-gain buffer, programmable gain amplifier (PGA), transimpedance amplifier, up/down mixer, sample and holder filter and analog-to-digital modulator.

The unity gain bandwidth of the SC/CT units is 6MHz and when used



This CY8CKIT-010 development board has an onboard PSoC5 chip (other side of PCB) and can be used to evaluate this chip and also develop and test circuits based around it. It also comes with Windows software and documentation.

as programmable gain amplifiers, the gain can be set in the range of -49 to +50. They can work with internal or external signals (via a GPIO pin).

When used as transimpedance amplifiers, the SC/CT units convert voltage into current with a selectable gain of between 20V/mA and 1000V/mA. The output can also be offset by a reference voltage, fed into one of the block inputs from an external or internal source.

When an SC/CT unit is used as an up-mixer, the two input frequencies can be up to 1MHz. When used as a down-mixer, the input signal can be up to 14MHz and the output up to 4MHz. When configured as a modulator, the SC/CT unit can be used to help build a very accurate low-frequency ADC system, suitable for measuring the output of strain gauges, thermocouples and so on.

These configurable blocks are most useful for those and similar measurement applications however they could also be useful for other tasks. For example, PGAs are useful in any situation where you want to digitise a signal with a wide dynamic range as they can be placed in front of an ADC and therefore allow its effective full-scale voltage to be dynamically adjusted.

Power efficient design

One of the main focuses of Cypress' PSoC series appears to be power efficiency and the PSoC 5 has a number of features which allows the power consumption to be adjusted between a very low level, for applications which require it, and a higher level where more processing power is required.

The internal synchronous boost regulator mentioned earlier is a particularly nice feature. It will operate with an input voltage as low as 0.5V!

That means that the whole system-on-a-chip can be run from a single alkaline or NiMH cell with very few additional components. It can even be used if you are not running from a battery, eg, if you want to run the chip from a 1.8V supply but need 3.3V for some other purpose (eg, to drive an LCD), it can produce that too.

Also, the whole system will run with a supply voltage from 1.8-5V meaning that you only need to boost that single cell voltage up to 1.8V, minimising wasted power. The system can also run directly from a single LiIon or LiPoly cell.

The PSoC5 core runs at 1.8V, regardless of the I/O voltage (as mentioned, it can be up to 5V). This is achieved via internal 1.8V regulators. There are several, as different ones are used during normal operation, sleep and hibernate modes (the latter two having very low quiescent currents). There is also a low-power 32.768kHz real-time clock and oscillator circuit for timekeeping which operates even in the power-down modes.

Like many micros, the clock system and PLL are quite flexible and the micro's clock rate can be varied to change power consumption depending on requirements and over time.

Power saving is also possible in the analog circuitry. For example, the comparators can be set to fast, slow or ultra-low-power modes which give different trade-offs between speed and power consumption. Similarly, the op amps can be set to be slow, medium or fast. Because the analog circuitry can run from such low supply voltages (eg, 1.8V), virtually all the analog components have rail-to-rail inputs and outputs.

The LCD driver is also designed to consume as little power as possible, for use in portable equipment.

With all the circuitry on this chip, you'd expect its power consumption to be quite hefty when operating. But its quiescent current is just 3.1mA with the analog and digital units powered up and the microcontroller executing instructions at 6MHz. This means that with a 1.8V supply, the power consumption is just 5.5mW which is rather impressive.

The power consumption will presumably rise when the chip is active and analog signals are being processed.

Digital features

There are some fancy features on the digital side of the chip, too. We've already mentioned the Universal Digital Blocks which, according to Cypress, are "a collection of uncommitted logic (PLD) and structural logic (Datapath)" and can be used to create all common embedded peripherals and customised ones too.

They give some example peripherals you can build using these UDBs: I^2C transceivers, UARTs, SPI (serial peripheral interconnect) transceivers, external memory interfaces, PWMs, motor control, timers, counters, logic (NOT/OR/XOR/AND), cyclic redundancy check (CRC) generators and so on.

PLD stands for "Programmable Logic Device" and is a small chunk of configurable logic similar to the CPLDs and FPGAs mentioned earlier. The "Datapaths" each consist of an 8-bit arithmetic/logic unit (ALU), a FIFO queue (first-in, first-out), data registers, accumulators, barrel shifter and mask unit, plus routing and configuration.

Clearly, combined with the PLD blocks, this is quite a powerful system for building the aforementioned types of digital circuits and more.

The "Digital System Interconnect" (DSI) is used to route signals between the GPIO (external) pins, microcontroller I/Os, UDBs, interrupts, DMA and other systems.

Digital filter block

Then there is the Digital Filter Block (DFB) which is a DSP-like construct.

This can be used to implement Infinite Impulse Response (IIR) or Finite Impulse Response (FIR) filters. These are commonly used with oversampling ADCs and DACs to prevent aliasing and other undesirable artefacts when dealing with high-frequency signals.

It can also be used to form digital notch, low-pass, bandpass, high-pass or arbitrary shape filters for general use. The DFB has a single-cycle 24-bit multiply/accumulator and can be used to generate up to a 64-tap FIR filter or four 16-tap FIR/IIR filters.

Other features

As if that was not enough, Cypress has added some other features to make the developer's life easier. There are extensive debug and test interfaces including JTAG, Serial Wire Debug (SWD) and TRACEPORT. It also has several embedded debug and trace units plus the ability to re-flash itself using an I²C, SPI, UART or USB interface.

So that the chip can interface with other external circuitry easily, it's possible to run some pins at a certain I/O voltage level (say, 3.3V) while others can operate at 1.8V or 5V. In fact there are four VDDIO pins which can all run at different voltages in the range of 1.8-5V and they control separate banks of digital I/O pins.

The USB interface can run from an internal oscillator, saving a crystal and associated components, if desired. Some PSoC5 chips also have a CAN (Controller Area Network) interface built-in. Plus all these chips support "Capsense" which means that you can implement capacitive touch pushbuttons with no external components but just use PCB traces.

Limitations

This all sounds very clever and it seems that you could build quite a powerful signal acquisition and processing system using a PSoC 5 chip and little else. But there are some disadvantages compared to discrete solutions. For a start, the internal analog multiplexing inside the PSoC chip adds significant series resistance to the signal paths.

There are two types of internal analog switches, small and large, with a nominal on-resistance of 870Ω and 200Ω respectively. This can affect the accuracy of gain set by external resistors and requires careful design so that this resistance doesn't interfere with filter constants or other operating parameters of the system being designed.

Then there's the cost. A PSoC5-series chip starts at around $14 (64KB flash, 16KB RAM, 64 pins) and the more powerful versions are around the $35 mark (256KB flash, 64KB RAM, 100 pins). However when you consider how many additional chips you might need to perform the same task and how much PCB area will be saved, those prices start looking quite reasonable, even when you consider that a similarly powerful microcontroller (ignoring all the analog magic) costs around $3.

Another possible drawback is the fact that the 67MHz Cortex-M3 32-bit processor in the PSoC 5 is nowhere near as powerful as a proper DSP chip. However, that is partially mitigated by some of the features of the PSoC5 which reduce the amount of work the processor must do, such as the digital filter block.

Still, in many applications, a powerful DSP is what you need. One option may be to team the two together, using some Universal Digital Blocks to form a high-speed interface for data exchange. For comparison, a 200MHz Blackfin DSP starts at around $6 and 400MHz at around $9.

Then again, DSPs are (currently) much higher volume chips than the relatively new PSoCs. Perhaps, given time, that will change. We certainly like the idea of being able to do for analog processing what FPGAs can in the digital realm.

Getting into PSoC

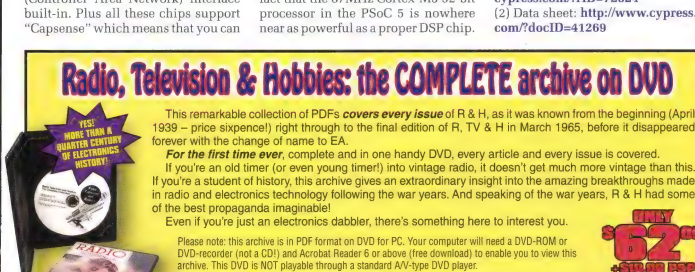
If you're interested in trying out the PSoC series of chips, there are some evaluation boards available. The CY8CKIT-010 is a small PSoC5 development board which comes with Windows software and documentation. This kit costs $60-$90 and is available from element14, Digi-Key and Mouser.

There is also a more comprehensive (and expensive) development kit called CY8CKIT-001 which has an LCD, breadboard area and some other circuitry but its availability is limited.

Useful links

(1) General information: **http://www.cypress.com/?rID=72824**

(2) Data sheet: **http://www.cypress.com/?docID=41269** SC



THE ONE THAT GOT AWAY . . .

A RATHER POINTLESS PROJECT!

SILICON CHIP staff design a lot of projects – and 99% of them appear in the magazine. Very occasionally, though, we have one that doesn't work – or doesn't work as intended – and in journalistic parlance, it's "spiked". Here's the story of one project that *did* work perfectly but *still* didn't make the grade. Only after it was built and tested did we come to the realisation that there was simply no point! Why then are we publishing it? Because it's an interesting idea, if nothing else!

It all sounded really good in theory. Take one of those ubiquitous, cheap 3-cell ultrabright LED torches and add some circuitry that not only increased the battery life but also the life of the LEDs themselves.

And while the project here does just that, it doesn't make any economic sense, given that you can buy these torches for next-to-nothing, either from bargain shops or on line. Also given also that AAA cells are really cheap, no-one is likely to begrudge replacing them every now and then.

If you've used one (or more!) of these torches, you've probably found two problems: (a) the batteries don't last very long and (b) the LEDs tend to fail much quicker than you would expect.

As we'll explain, both of these problems have the same root cause – to get the very bright light output, the LEDs are driven much harder than they should be, putting them in mortal danger. That extra current has to come from somewhere, so the batteries don't last long at all.

Design by John Clarke
Article by Ross Tester and John Clarke

So what do you do if they fail? Because they are so cheap, most people chuck the old one in the bin and buy another!

So the theory behind the project is perfectly sound and it may well be that some readers may wish to adapt this circuit for other uses. Indeed, some may wish to build this for exactly the reason we designed it, just for the sake of doing so.

It won't be an expensive project; the parts will be readily available from companies such as element14 (and the PCBs will be stocked by SILICON CHIP PartShop, just in case).

One caveat; this was designed specifically to suit those small 3 x AAA torches. It is not suitable for use with higher voltage models (eg, four or six AA, C or D batteries etc).

Anyway, enough of our sob story. Let's have a look at the design – we are publishing both the circuit and component overlay just in case you *do* want to put one of these together.

Typical torches

Low cost AAA LED torches

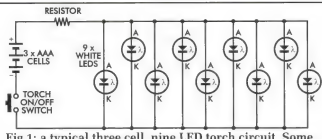


Fig.1: a typical three cell, nine LED torch circuit. Some torches will have a resistor to limit current but many will have none, with a direct connection between the cells and LEDs. The LEDs are all paralleled.

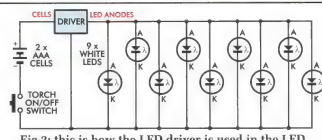


Fig.2: this is how the LED driver is used in the LED torch. It replaces the top (cell 3) AAA cell. The torch then runs from two AAA cells with lower current because the LEDs are not being driven as hard.

tend to have a common design. Housed in an aluminium body, the light source usually comprises some nine LEDs with the three AAA cells arranged in a triangle pattern (side by side) within a holder. A switch is located at the bottom end of the torch. The circuit arrangement is shown in Fig.1.

The three AAA 1.5V cells are connected in series to obtain a nominal 4.5V supply with fresh cells. The switch connects the negative terminal of the battery to the aluminium case, making connection to the cathodes of the paralleled LEDs.

Some torches include a current limiting resistor as shown, connecting between the LED anodes and the battery plus terminal. But in many torches there is no resistor.

With the torches we tested, the LEDs were severely overdriven, even including one that has a 2.2Ω limiting resistor instead of a direct connection of the battery to the LEDs.

Yes, they're bright – but they won't last long.

Our driver

The LED driver replaces one of the AAA cells. The circuit arrangement is shown in Fig.2.

The design is such that the bottom of the LED driver PCB has contact with the plus side of cell 2. The LED driver negative connection is made with a length of wire to the torch case via the LED cathodes of the torch. The top end of the PCB is the anode output for the LEDs.

Circuitry for the LED driver is shown in Fig.3. This is based around a single cell DC-DC converter, IC1, a low saturation voltage transistor (Q1) and inductor, L1. Supply for IC1 is directly from the two series connected AAA cells. The IC can operate down to 1.1V and this means that each AA cell each would be discharged to a rather flat 0.505V before IC1 stops working.

Circuit operation begins with transistor Q1 being switched on via base drive from the Vdrive output. This allows inductor L1 to charge up via the 3V supply, Q1 and resistor R1 . Transistor Q1 has very low saturation voltage (at around 10mV) which minimises power losses. Inductor current is sensed across the 150mΩ resistor.

The inductor is charged until voltage at the Isense input (pin 5) reaches 25mV. This is at a current of 166.6mA and the transistor Q1 is then switched off for 2.5µs, allowing the inductor current to flow into the paralleled LEDs. For the nine LED torch that current is 18.5mA per LED. After the discharge into the LEDs, transistor Q1 is again switched on and L1 recharged.

Note that the LEDs are pulsed rather than continuously lit.

Inductor (L1) has a lower inductance and a higher DC resistance than is optimal for minimal power loss but was selected so that it would fit in the AAA cell space. A higher value inductor or one with a low DC impedance would be physically larger.

Power from the AAA cells is bypassed with a 1µF capacitor. A Schottky diode connected across the supply is there to protect the circuit should the cells be inserted into the cell holder with reverse polarity. The diode shorts the battery voltage, restricting reverse voltage across IC1.

Construction

We're not going to go into a lot of detail on construction because we don't think many will be built.

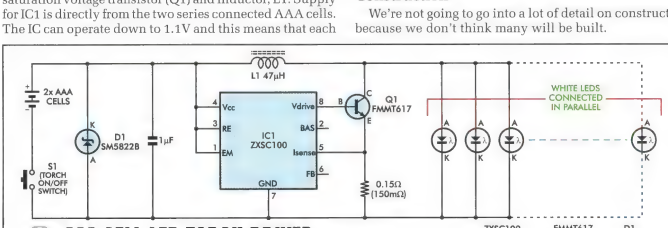


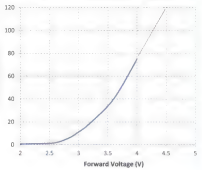
Fig.3: based on a single cell DC-DC converter, inductor L1, is first charged with Q1 conducting and when current reaches 166.6mA (25mV across the 150mΩ resistor), the transistor switches off and the inductor current flows through the LEDs.

Driving LEDs in low cost torches

Typically, low-cost AAA LED torch manufacturers do not power the LEDs correctly, applying excessive current with fresh cells. They apply this excessive current either via a direct connection of the LEDs to the AAA cells or via a low value resistor.

The reason for over-driving the LEDs is probably so that the torch appears to be very bright. But this brightness is at the expense of the LEDs. So what are the consequences for the LEDs?

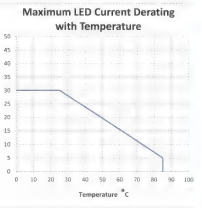
The graph at right shows the typical forward voltage of the LED with current. For a direct connection of a 4.5V battery to the LEDs we can expect some 120mA through each LED. In practice the current does not quite reach this extreme due to the internal resistance of the battery. With nine LEDs, the battery cannot deliver 120mA to each of the nine LEDs, just over 1A total. LED current is therefore not quite so severe. Actual LED current will depend on the cells, whether alkaline or zinc-carbon, and the cell voltage.



Another complication with paralleled LEDs is that they do not share the current equally. The differences between each LED's forward voltage with current will mean that some LEDs will draw more current than others. That imbalance is made worse as the higher current drawing LEDs increase in temperature and draw even more of their share of the current. For equal current sharing, the LEDs should be connected in series and driven from a higher voltage current limited driver.

We use the words severe and extreme when mentioning the LED current because 5mm LEDs are just not rated for the current they are subjected to. Absolute maximum for any 5mm white LED that we can find among 10 well-known LED manufacturers is 30mA. And that maximum current is at 25°C ambient temperature. But at a room temperature of 25°C, we measure the LED housing temperature at some 36°C when each is driven at 20mA. This temperature rises to as high as 53°C at 100mA per LED.

The lower graph shows that maximum LED current at 36°C is about 25mA and below 20mA at 53°C. This graph is typical of most 5mm white LEDs and shows that the LEDs when directly driven from a 4.5V battery are severely over driven when compared to the recommended current of 20mA.



However, we have shown the component overlays for both sides of the PCB (Fig.4) just in case. . .

One point to note is that inductor L1 is mounted unconventionally – it fits within a rectangular cutout in the PCB. And if you're trying to shoe-horn the PCB into a torch housing, you'll almost certainly need to lay over the 1µF capacitor to give clearance.

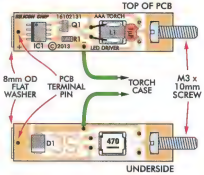
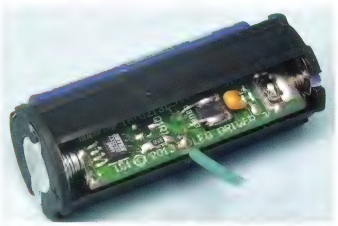


Fig.4: component overlay diagrams showing both sides of the double-sided PCB. Q1 and the 150mΩ resistor are surface-mount components soldered to the top side of the PCB. The SMD diode (D1) mounts on the underside of the PCB.

These two oversize photos show the same view as the diagrams above; ie, of the top and bottom sides of the PCB respectively. They clearly show the way we mounted the washer and screw which form the connections to the torch.



And here's how the PCB fits inside the 3xAAA battery holder, replacing the top cell. The green wire emerging from the PCB connects to the torch case forming the negative connection. The most convenient connection point is actually the copper track for the LED cathode connection points on the PCB shown above right.

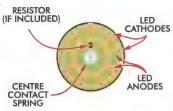


Fig.6: this tiny PCB is found in most mini torches and is the way the LEDs are mounted, to connect to the battery pack. Not all torches have the series resistor – but even in those that do, it doesn't achieve a great deal!

Finally, the way the whole thing is assembled (whether it has the standard three cells or two cells and our driver circuit). And while our driver works fine, at the price these mini torches sell for it's hardly worth the effort!

Parts List – LED Torch Driver

1 PCB coded 16102131, 42 x 10mm
1 9-white LED 3-AAA cell torch
1 47µH 1.1A 230mΩ inductor 6x6mm SMD (L1)
(Murata LQH6PPN470M43L
[Available from Element14 Cat. 778-2814])
1 M3 x 10mm pan head screw (head diameter 5mm, 2mm thick)
1 flat washer 8mm OD
1 PC stake
1 25mm length of 0.7mm tinned copper wire
1 50mm length of medium duty hookup wire

Semiconductors

1 ZXSC100N8TA single cell DC-DC Converter (IC1)
[Available from Element14 Cat. 113-2759]
1 FMMT617 NPN switching transistor (Q1)
[Available from Element14 Cat. 952-6420]
1 B320A 20V 3A or SM5822B 40V 3A Schottky diode (D1)
[Available from Element14 Cat. 185-8605 or Jaycar ZR1025]

Capacitor

1 1µF monolithic multilayer ceramic

Resistor

1 150mΩ 250mW 1206 SMD (Yageo RL1206FR-7W0R15L
[Available from Element14 Cat. 806-7597]
(for a 6-LED torch use 220mΩ 250mW (Yageo RL1206FR-7W0R22L). [Available from Element14 Cat. 8067600RL]

Tests

We ran some discharge tests using some commonly available torches including two torches that had a direct connection between the battery and LEDs and another (Xtreem brand) that included a 2.2Ω limiting resistor. The discharging was continuous, meaning that the LEDs were driven until the cells became flat. You can expect more life from the batteries in normal use when the torch is only run for short periods.

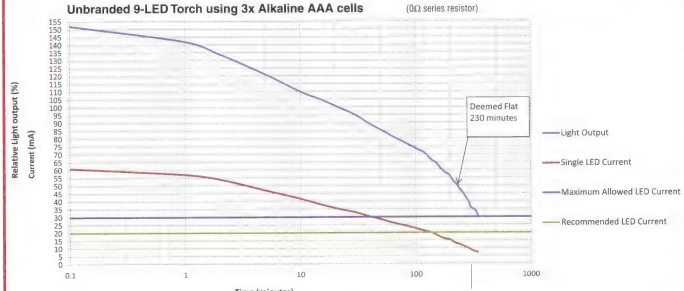
To enable direct comparisons we set the 100% reference light output level as the initial value for the Xtreem torch using Extra Heavy Duty (Zinc-carbon) cells. That's also the light output from the same torch after 10 minutes using Alkaline cells. We arbitrarily deem the batteries flat when the light output reaches 50% of the 100% level. LED current was calculated by measured the voltage drop across a 0.1Ω resistor in series with the LEDs.

Light output was measured by shining the LEDs onto a 1.5V solar cell panel using a jig that held the light beam in a consistent position and that prevented ambient light entering the panel. The output from the solar panel was measured by placing an 18Ω load across the terminals and measuring the voltage across this resistor. The measurement effectively is short circuit current flow. Output voltage from the panel at the 100% level was 153mV.

The graphed LED current is that calculated from the total torch current for an individual LED.

So for a nine LED torch, the total torch current was divided by 9. To calculate the current drawn from the AAA cells multiply the individual LED current by nine.

The discharge curve shows the point where each AAA cell reaches 1V. At that voltage the cell can be considered flat. SC



Vintage Radio

By Rodney Champness, VK3UG

Seyon 2D 2-valve "wireless" & an old single-valve receiver

This month, we take a look at a Seyon mid-1920s wireless set and another set of unknown age that was probably built (or rebuilt) between the 1920s and the late 1930s. Both sets are owned by Mark Bennett and I have used the term "wireless" deliberately, as these sets are definitely from the era when the term "wireless" was used instead of "radio".

ALTHOUGH FROM the same era, these two sets are quite different. The Seyon is a 2-valve receiver and was manufactured by the Noyes Brothers. How did it get its name? Well, "Seyon" is "Noyes" spelt backwards.

The other set uses a single valve only but its origin is obscure. It has "E. Mills" marked on its baseboard but it's unknown whether this was the owner, constructor or manufacturer.

The Seyon 2D

For a 2-valve wireless set from the mid-1920s, the Seyon is quite small and is remarkably well laid out. The set featured here was probably built in 1926, as the bias battery fitted to it has a warranty expiry date of 1927 and the valves specified came onto the market in 1926. In this set, however, the A425 valve (which was down on performance) has been replaced with an A415 which came out in 1927.

A card inside the back panel of the set shows the various connections for the batteries, antenna and earth. In fact, it's rather unusual for such an old receiver to have such useful information attached to it, although it's not as extensive as the information available on some later receivers. However, it still gives enough information for the average person to make the connections and get the set going.

The information card would have also minimised any errors when it came to connecting the batteries and fitting the valves. Unfortunately, it was not uncommon for batteries to be incorrectly attached to the receivers of this era and this could cause big problems. For example, attaching a high-tension (HT) battery to the valve filaments was certain to wreck the

valves, which could be heart-wrenching. Valves were very expensive in those early days!

The front-panel photo clearly shows the lack of control markings, something that was common during the early days of radio. The tuning dial is an "Indigraph" with a simple numbered dial scale.

The lefthand side of the front panel carries the regeneration control, which is a Bakelite-enclosed 360°-rotation variable capacitor. Next comes the main tuning dial and this is adjusted using a vernier drive on its lower edge. The only other front-panel component is a jack socket, used for connecting either headphones or a sensitive loudspeaker.

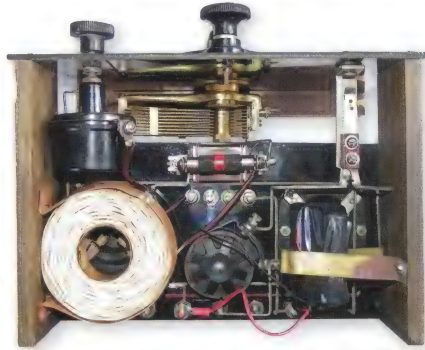
In addition, the set has a filament rheostat but this is mounted on the top of the chassis, towards the rear behind the audio interstage transformer. This rheostat has an open circuit section at one end, so that the set can be turned off.

As far as the cabinet goes, this isn't a "coffin set" as such, although it does have a lid that lifts up. However, it was innovative for its time, with a conventional chassis and an attached front panel. The entire assembly can be slipped out of the cabinet once the retaining screws in the front panel have been removed, along with the battery, antenna and earth leads (these go into Fahnstock clips along the back of the chassis).

As shown in the photos, the wiring connections are run directly to terminals bolted to the ebonite chassis (this is an insulator and so no additional insulation is needed). The speaker currently used with this receiver is a German-made Neufeldt and Kuhnke unit, made in Kiel. It is a high-impedance (1.35Ω) reflex design and is remarkably effective.

One minor problem with the underchassis layout is that both valve sockets are hidden, one under the unusual-looking tuning coil and the other under the bias battery. This makes access for servicing more difficult.

An above-chassis rear view of the 2-valve Seyon receiver. Note the large interstage audio transformer between the two valves and the row of spring terminals along the rear edge to terminate the battery connection leads.



An under-chassis view of the Seyon receiver. The grid-leak resistor (below the tuning capacitor) required replacement, while three 1.5V AA cells connected in series (and taped together) now provide the bias voltage.

The circuit

Mark doesn't have a circuit for this set so I can only surmise that it is a conventional 2-valve receiver for the era, using a Philips A425 as a regenerative detector. This is followed by an Igranic interstage audio transformer with a step-up winding ratio of about 1:3. It feeds the audio signal to an audio amplifier output stage which is based on a Philips A409 valve. Its plate circuit drives either a high-impedance speaker or a pair of headphones.

For those unfamiliar with their use, an interstage audio step-up transformer increases the signal voltage at the plate of the triode driver valve before applying it to the next stage. A step-up ratio of 1:3 is common but ratios as high as 1:7 have been used. The higher the ratio, the poorer the audio quality, so 1:3 was generally considered to give the best compromise.

Interstage audio transformers were suited to the relatively low-gain triode valves of the era. If the practical gain of

Inside of the Seyon receiver with the lid raised. The label attached to the rear panel shows how the batteries, antenna and earth are connected to the set.

the A425 was 20 and the transformer had a step-up ratio of three, then the overall gain would be 60.

One drawback was that these transformers were expensive to produce. As a result, they disappeared as higher gain tetrode and pentode valves came onto the scene and RC interstage coupling became popular. For example, the 6AU6 valve has a gain of up to 371, so why would you bother with a transformer when a few low cost components would do a better job! Manufacturers ceased using interstage transformers when valves such as the 6AU6 came on the market.

Despite its age, the original bias battery, a Yale flashlight type, still had an output of 1.3V.

Even humble triodes like the 6AV6 will amplify signals by up to around 70 times in a practical RC-coupled circuit. What's more, the resulting audio quality is much better than through the best audio transformer.

Battery triodes

Both the A409 and the A425 are 4-pin battery triodes with 4V filaments, each drawing 65mA. The A409 has a theoretical gain of nine although it will be probably be around seven in most practical circuits. A plate voltage of up to 100V can be used and the valve will draw 8mA with a bias of up to -9V.

By contrast, the A425 has a theoretical gain of 25, although this will be reduced to around 20 in practice. It can be used with up to 120V on the plate and will draw around 1mA with a bias of around 1V.

Power for the Seyon receiver was supplied by a 4V lead-acid accumulator for the filaments, a 4.5V battery for the bias and two dry batteries tapped at various voltages for the high tension (HT). The original filament and HT batteries had long since been discarded when Mark obtained the set but the original bias battery (a Yale No.117 flashlight type) was still there. A test of this battery revealed that it could still muster 1.3V – this some 85 years after it was manufactured (the warranty expired in December 1927).

Mark now uses a mains-operated power supply with the set, along with three 1.5V AA cells to supply the bias voltage. These AA cells are taped together, clamped under the chassis and connected via the only plastic insulated wire in the set. Sometimes, wire that's authentic for a particular era is not easily obtainable.

The external mains-operated supply provides the two HT voltages required by the set, plus the 4V supply for the filaments.

Restoration

As indicated previously, the original A425 valve was down in performance. Mark replaced it with an A415 which although lower in gain, still works well in this receiver. In addition, the grid leak resistor, like many of that era, had gone open circuit. As a result, it was dismantled and re-cored with a small, modern resistor. The capacitor in that assembly was also checked with a high-voltage tester and found to be in working order.

Performance

Once the repairs had been completed, the Seyon performed quite well for a 2-valve receiver. It does not need a large antenna and it will drive a high-impedance speaker to reasonable volume when tuned to local radio stations. The regeneration is controlled primarily by the regeneration control on the front panel, with further control afforded by adjusting the filament rheostat.

Like most sets of the era, the dial scale is marked 0-100. As a result, most listeners made up a chart showing the stations and their corresponding numbers on the tuning dial. This enabled them to quickly tune to a particular station at any time.

The 1-valve set

I'm uncertain as to the origin of this little set but I'm inclined to think that it was home-made rather than commercially manufactured. The reason for this is that the circuit assembly could hardly be described as first class, especially when compared to the Seyon. On the other hand, the cabinet was obviously made by someone who knew what they were doing although it was rather dilapidated when Mark came by the set.

As shown in one of the photos, the

various controls are arranged across the ebonite front panel. These are, from left to right: the regeneration control, the tuning control and a filament rheostat with an on-off position. Underneath the tuning control are two terminals which are used to connect the headphones or a horn speaker to the set.

The battery leads are fed directly out of the battery compartment and the antenna and earth points are connected via flying leads to terminals on the lefthand side of the cabinet.

Circuit details

This 1-valve set is typical, both in circuitry and cabinet style, of the many simple receivers built in the 1920s and 1930s. It uses a single type 30 valve in a regenerative circuit (see Fig.1) and this directly drives a pair of high-impedance headphones or, if the received station is strong enough, a high-impedance horn speaker. In fact, Mark uses this set from time to time with a Browns horn speaker.

The 30 valve is classed as a detector/amplifier triode. It has a 2V 60mA filament, can be used with up to nearly 160V HT, requires a bias of up to -15V and will draw 1-3mA of plate current, depending on the operating parameters selected by the designer.

The gain of the valve in class-A mode is around nine, which is quite modest. However, when used as a regenerative detector, this low gain is largely made up for by the feedback network. A pair of 30 valves arranged in a class-B push-pull configuration can give an audio output of 2.1W, which is similar to that derived from 19 or 1J6G twin-triode valves used in the same way.

In this set, the 30 valve has a 25Ω rheostat in the filament line and this acts as a subsidiary regeneration control and on-off switch. It certainly suggests that the 30 will work quite well with less voltage on its filament than 2V. Indeed, if the rheostat is set to full resistance, there will only be about 1.2V across the filament.

As an aside, many "do-it-yourself" designs published during the era used a 1.5V torch cell to provide the filament voltage. The valve worked quite well with this lower voltage and 45mA of filament current.

Getting it working

Despite looking a bit tatty, the circuit breadboard didn't require any major

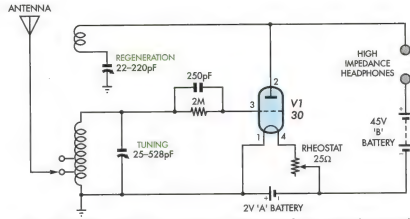
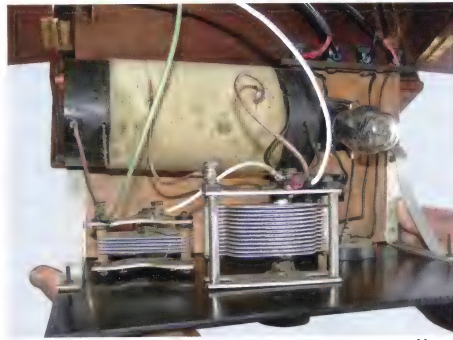


Fig.1: the circuit for the 1-valve receiver. It's a simple regenerative set with a type 30 triode valve used as detector/amplifier. This directly drives a pair of high-impedance headphones or a high-impedance loudspeaker.



The chassis layout of the 1-valve set is as simple as it gets. It was restored by replacing the grid-leak resistor and cleaning up some of the wiring connections.

work other than fixing a faulty grid-leak resistor and cleaning up some wiring connections. The grid-leak resistor was fixed by removing it from its case (by drilling it out), then sliding in a new resistor and soldering its leads to the capped ends. This is a neat method that keeps the components looking original.

The mica capacitor across the grid leak resistor is a different type to that used in the Seyon and it checked OK. However, some of the wiring had deteriorated so much that it had to be replaced. In addition, some of the wiring connections had corroded, so these were cleaned up and the terminals re-tightened. The 30 valve was in working order, as were the remaining passive components.

Power supply

To power this set, Mark uses a small 12V sealed lead acid (SLA) battery and a linear regulator circuit to provide 2V for the filament. This may not be an efficient method of supplying the filament current but it is convenient, as the set is not used a great deal.

By contrast, the 45V HT for the plate circuit is provided by five 9V 216 batteries wired in series. These are daisy-chained together to give a spare terminal at each end which is then connected to the receiver. A battery snap connector cut in half makes the

The cabinet for the 1-valve set was restored by stripping off the gold paint, then sanding and staining the timber. The doors and hinges were replaced.

This Browns horn speaker is often used by Mark with the 1-valve set.

connections to the battery terminals.

As shown in one of the photos, the 9V batteries are taped together and sit in the cabinet's battery compartment.

Cleaning the controls

The next step in the restoration involved cleaning the control knobs. This was done using soapy water and a small scrubbing brush. The knobs were then polished (using car polish) and rubbed clean with a soft cloth to remove any old oxidised Bakelite.

The markings on the knobs had disappeared long ago so the indents in each control were then hand-painted in white. The paint was initially applied over the indentations with no particular care and the knobs then wiped using a cloth moistened with turpentine. This removed all the paint except from the indentations and grooves, leaving a neat finish. This technique proved so successful that the controls now look like new.

Cabinet restoration

The cabinet restoration required a considerable amount of work. The original cabinet (doors included) was covered with ugly, gold-coloured paint which really looked out of place, especially as the timber underneath was quite attractive. As a result, the cabinet was dismantled along all hinged edges, so that all the corners and edges could be easily reached during the restoration work.

As well as being covered in gold paint, the doors were also in rather poor condition. These were replaced by two new doors made by Dennis, a friend of Mark, while another friend (Marcus) turned up a new catch. In addition, all the old hinges were discarded and new brass hinges of the same general style obtained to go with the cabinet.

The rest of the cabinet was restored by first applying paint stripper to remove the gold paint. The cabinet was then sanded down along the wood grain using progressively finer grades of sandpaper to obtain a smooth finish. A product called "Feast Watson" (a wax-enriched timber oil) was then applied to the cabinet using a soft cloth and this gave the timber a rich golden-brown finish.

The batteries for the 1-valve set sit in a special battery compartment at the bottom of the cabinet.

Summary

Mark, with help from Marcus and Dennis, has restored both of these early receivers to good working order. Generally, Mark ferrets out suitable sets for restoration, Marcus does the technical restoration and Dennis does the cabinet work. So it's a collaborative effort.

The Seyon receiver is particularly interesting because it uses a chassis, with components mounted both above and below it. This construction technique wasn't all that common when the Seyon was manufactured.

Both sets are quite collectable, particularly the 2-valve Seyon. It offers better performance than the 1-valve set but the latter has a more impressive cabinet. SC

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12AX7 VALVE AUDIO PREAMPLIFIER	NOV 2003	01111031	$25.00
POOR MAN'S METAL LOCATOR	MAY 2004	04105041	$10.00
BALANCED MICROPHONE PREAMP	AUG 2004	01108041	$25.00
LITTLE JIM AM TRANSMITTER	JAN 2006	06101062	$25.00
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CDI MODULE SMALL PETROL MOTORS	MAY 2008	05105081	$15.00
LEDILAMP FLASHER	SEP 2008	11009081	$10.00
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6-DIGIT GPS CLOCK DRIVER	JUNE 2009	07106991	$25.00
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TOSLINK TO S/PDIF/COAX CONVERTER	OCT 2010	01210102	$10.00
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ULTRA-LD MK3 INPUT SWITCHING MODUL	NOV 2011	01111112	$25.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$30.00
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CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
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2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
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PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC18F1320-I/SO	Intelligent Dimmer (Apr09)
PIC32MX795F512H -80I/PT	Maximite (Mar11), rumiMaximite (Nov11), Colour Maximite (Sept/Oct12)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolour (Nov12)
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Ignition for a Moto Guzzi V-twin motorbike

The ignition system recently published (November & December 2012) is great but how about doing a twin output version to suit V-twin motorbikes such as my rare Moto Guzzi which I am restoring? I need the ignition module to be as compact as possible to make it easy to mount on the bike.

The idea is that there would be one PIC controlling two IGBTs to drive two separate coils. You would have one timing signal from the bike and the second coil timing has to be adjusted to suit the bike which might be a 60° or 90° V-twin. I suppose the idea could be extended to flat twins such as BMWs as well. Is this idea feasible? (O. O., via email).

● With most twin-cylinder engines there are two separate coils and two triggers, so the ignition system for each cylinder is separate. If only one trigger signal were used (thus saving the components to provide the input for the second trigger) then the second firing would have to be calculated based on the one trigger signal. This takes at least two trigger signals before the calculation can be made and so at start-up, the firing for the untriggered cylinder will be missing and possibly quite unsteady at low RPM. Any variation between successive firings due to RPM changes or due to irregular RPM at low revs will cause an inaccurate firing for the calculated firing point.

This could make it hard to start the bike and it might run like "a hairy goat" at low speeds; not good.

It is true that we generate the dwell period in software in our ignition by predicting when the next firing will occur based on the period between successive firings and adding a dwell period before the predicted next firing. However, dwell is not so critical whereas the firing point is.

Any acceleration or deceleration of the engine actually affects the calculated dwell period, increasing dwell on deceleration and reducing it on acceleration. That variation for a calculated firing point will have the firing point vary until constant RPM is restored. Again, this could result in rough running.

The Programmable Ignition calculated firing based on the trigger signal and was prone to this problem but we had the advantage that the trigger signal for each cylinder was still available and so advanced firing could never be delayed beyond the trigger signal. The retarded firing could be easily made close to being correct since it would only be a short period after the trigger signal.

On the other hand, it may be possible to produce a two-output version by having two cylinder firing signals feeding one PIC microcontroller which would then drive two IGBTs. However, we would have to use a faster microcontroller and employ quite a few surface-mount components to keep the overall PCB and module size the same.

Another Moto Guzzi motorbike

I have a Moto Guzzi 400cc V-twin motorcycle. It currently has a Boyer Bransden kit fitted to it with a modified Hall effect trigger. The trigger has a 1-coil stator and a two-magnet rotor. The "black box" feeds into one coil to fire both cylinders. The "black box" is not programmable and although the bike runs, the performance leaves a lot to be desired because it is very retarded. I needed a programmable ignition system.

Imagine my joy when a friend pointed me in the direction of the Jaycar kit for your Programmable Ignition (SILICON CHIP, March to May 2007). The advertising said one to 12 cylinders. On reading the documentation I discovered, buried on page five, that the unit, singular, will not work on a V-twin. Please remember my bike has one stator coil with two rotor

Alternative Output Filter For The Classic-D Amplifier

With respect to the Classic-D Amplifier (SILICON CHIP, November & December 2012), I believe a multi-pole filter (as I have attached) will greatly improve the high-frequency distortion and slightly improve the phase shift as well. Note that all inductors would need to be turned at 90°.

I would love to see a comparison review. (J. C., via email).

● There would be some benefits to using a multi-pole filter but it's a bit impractical and we don't think it will have a particularly large effect on high-frequency distortion. The inductor we have specified is very linear and is not a great source of distortion.

Those types of inductors, specifically designed for this application, are only available in relatively few values so your design would probably require multiple hand-wound air-core chokes to get the right values. These would have a higher resistance than the ferrite type we've used and so would get hot (possibly very hot) and reduce the efficiency of the amplifier.

There is another, easier way to lower the distortion which is simply to reduce the amplifier gain and then insert a preamp in front of it to compensate. It appears that the main source of distortion at higher frequencies is simply the fact that it has insufficient open loop gain to give a higher feedback factor. Reducing the closed-loop gain would allow it to make better use of the open loop gain that it has for error feedback.

magnets. Please imagine my current disappointment!

The documentation states "requires evenly spaced firing between cylinders". Surely all V engines have uneven firing intervals. I feel confused as to why a V-twin needs two units and a V4/6/8/12 will work with one. Can I fool the unit into thinking it is attached to a slow running V4 by altering the rev characteristics in the programming? Am I able to halve the revs to make it "think" it is attached to a V4? Or do you have another solution which would work for me please?

Having read the documentation, I like the unit. It appears to meet all my needs, apart from not being able to work with a V-twin. Help please. (G. G., via email).

- V4/6/8 engines that end up with uneven firing have dual ignitions (two distributors and two coils) to avoid the problem that the timing is not regularly spaced between each V bank. For those engines, they would use one Programmable Ignition per trigger and distributor. However, with many V engines with more cylinders than two (4, 6 & 8), it is possible to have regularly spaced ignition firing.

For your engine, the combined firing pulses are irregular. We do not have a solution to using the Programmable Ignition with irregular firing. That's because the Programmable Ignition software calculates the timing based on each trigger with the assumption it is evenly spaced. If the trigger is not evenly spaced as in a V-twin, it greatly complicates the software.

As noted in the answer above, it may be possible to come up with a new design which has two outputs and two separate cylinder triggering signals.

Flash trigger problem solved

I have a question regarding the Photo Flash Trigger project in the February 2009 issue. When all three time controls are on zero, hence no delay, I am unable to get it to operate. As soon as a delay from any one of three of the switches is introduced, it all works fine.

Are you aware of any modifications for this? I am not sure what exactly is happening but by putting a 47pF capacitor across pins 1 and 3 of IC7a, it seems to be fixed. Is this OK or would it upset timing accuracy? Or am I on the wrong track altogether? The camera is a Canon 400D DSLR. (M. D., Aveley, WA).

- You certainly are on the right track and your "fix" won't upset the unit's timing accuracy, as far as we can see.

It seems that our original unit must have relied on a lucky combination of propagation delays in some of the gates (especially IC8d and IC7a) to make it work when all three switches are set to "0". Your 47pF capacitor added between pins 1 and 3 of IC7a seems to be working by slightly increasing the delay for the "end of count" pulse arriving back to IC7a from IC8d, so that flipflop IC7a/IC7b does have time to set before it's reset again.

The same effect could probably be achieved by adding a small resistor, say 100Ω, in series with the track connecting pin 11 of IC8 to pin 1 of IC7a. This is what we would probably have done if we had been aware of the

Software Problems With Audio Test Interface

I have recently completed constructing the SILICON CHIP Virtual Audio Test Instrument Interface (VATII) as described in the September 2012 issue. Overall, I found the actual construction to be quite straightforward, especially using the high-quality SILICON CHIP supplied PCB.

Upon completion of the physical construction and after several checkout inspections I completed the case and mounted everything as per the original article. When it came to checkout time, everything went as outlined in the construction article (my system is running Windows 7). The new Plug and Play USB device was recognised, the standard USB audio drivers were installed and LED1 duly lit up. I then proceeded via the Control Panel to set up that hardware which was duly recognised as a "USB Audio Codec" and configured all the settings as detailed.

I then downloaded and installed Virtins Multi-Instrument 3.2; this is currently running in the "evaluation mode" with a few days left. I have now read the September 2012 review of the virtual instrument software several times. I'm not sure if I'm missing something or just being plain thick at this point but after many attempts and software setting changes, I cannot get the VATII and the Virtins 3.2 software to talk to each other! In fact, I can totally disconnect the USB connection to the VATII and the Multi-Instrument 3.2 software and the on-screen information does not change.

At this point I was considering problems with the VATII unit but further visual and basic supply rail voltage checks seem to indicate that everything is in accord with the circuit information. Right now, I am not sure which way to go next and am hoping that you may have some additional advice and guidance for me in terms of further checks of the Virtual Audio Test Instrument Interface, the connection with and the set up of the Virtins software, and hopefully some basic "how to" information in terms of using the resulting set up for best advantage by an "experienced" hobbyist constructor. (W. G., Dunedin, NZ).

- It sounds as if your Virtual Audio Test Instrument Interface is working as it should and is also "installing" on your Windows 7 based PC. This suggests that either your evaluation copy of Virtins Multi-Instrument 3.2 is for some reason not installing correctly or you are somehow not "driving" it correctly to achieve your desired result.

In our case, we initially found a few aspects of the Multi-Instrument software that did cause problems, such as having to click on the red "button" at upper left on the screen, to get the scope/analyser instruments to "run" (ie, to "listen" to the Interface). Similarly, you needed to click on the red arrowhead at upper right on the generator window, before the generator would run and send waveform information to the interface. These points are not self evident but after you do "get the message" (ie, that both of these icons are red for stopped and green for running), they cease to be a problem.

Perhaps you should go to the Virtins website again and this time download the MI 3.2 User Manual. This is a single PDF file of about 280 A4 pages and provides a lot of useful information.

Problems With Barking Dog Blaster

I have constructed a Barking Dog Blaster (SILICON CHIP, September 2012) as per the article and am having issues. I would consider myself an experienced kit builder so I think I can overlook the likes of dry joints or diodes around the wrong way. I'm not saying I don't do those things sometimes but in this case all the parts are orientated correctly as per the board.

Firstly, I have no flickering LED – it remains stubbornly off no matter what. I am powering the unit from my bench power supply at 12V and plenty of current overhead available. I hold the start button and power on. No LED. I release the button after a few seconds and press it again for the test tone. I hear a faint (but in the human audio frequency range) "cascading" tone signal (the best way I can describe it).

It sounds very much in the background, as though there is no volume behind it, and it goes for around a minute (or until I press the start button again). That should be the test tone. The article implies it is a steady tone. Mine definitely cascades/steps down in frequency.

If I press the start button again, I can hear the tweeters "clicking" again as described in the article but I can also hear the tone. Now my hearing is dull after years of playing music professionally so technically speaking I should not be able to hear anything, especially at the supposedly high volume levels this thing should chuck out. I can adjust the timing circuit with VR1 as described from a few seconds to minutes so that seems to be working.

There are some differences between the magazine and my project. I could only source P60NF06 Mosfets; the web reckons these are just higher rated versions of the P30NE series ones listed. Perhaps this is why mine doesn't work. Or it could be because I've used a 56Ω 10W resistor in the tweeter box (tweeters are as specified from Jaycar)? Or the standard 7805 TO92-style regulator? The voltage test with the chip removed shows 4.96V on the pins described.

The only other difference is I used the next-size down wire on the PCB-mounted transformer (the inductor in the tweeter box measures as per the magazine). I'm certainly no expert but I would have thought these substitutions would be OK for this project (aside from the Mosfets – I took a risk with those).

My main concern is the LED not lighting and the low output (which could be the transformer/Mosfet combo). (D. T., Christchurch, NZ).

- It's strange the LED doesn't flash, as the software does seem to work (ie, timer and piezo drive). Check first that the LED actually works by removing IC1 and applying 5V to pin 2 of the socket. If the LED doesn't light, then check its orientation (see errata, January 2013) and for dry solder joints. Or perhaps the LED itself is faulty. Check the resistance of the 560Ω resistor.

With the LED operational, reinsert IC1. If the LED doesn't flash, check that output GP5 goes high (although it must as the timer seems to work as VR1 is also powered via this output).

The P60NF06 Mosfets will not work in this circuit as they are not logic-level types. The P60NF06 require 9V or more on the gate to switch on fully, while the circuit requires a Mosfet that will saturate at a 4V gate signal (ie, a logic-level type). That's probably what's wrong with the operation, as the transformer will not be driven correctly.

problem. But since your 47pF capacitor seems to have fixed the problem anyway, just leave it in place.

Rolling code remote control has poor range

I have built your 3-channel UHF Rolling Code Remote Control (SILICON CHIP, August & September) and have fitted it to a roller door. It works well. The only problem that I have is range. The unit is fitted in a concrete block building and mounted on an inside wall at right angles to the roller door. It is enclosed in a polycarbonate case.

I have extended the antenna outside the enclosure and up the wall for 300mm. It only has an operating range of about 3m from outside the building and the metal door is not between transmitter and receiver. Is this the maximum range? Or is the set-up wrong? If so, what can I do? (H. B., Glen Waverley, Vic).

- The transmitter/receiver range should be 40m in an open area but this is likely to be reduced with obstructions. You should be able to obtain far more range than the 3m you are experiencing. The receiver antenna total length should only be 157mm rather than the 300mm length you have used. If you use a vertical length of wire 157mm long, do not also include the coiled antenna shown on the overlay.

For the transmitter, make sure the antenna wire link is also included as well as the coiled section. The wire link and coiled section in total comprise the antenna length. Finally, make sure the metal roller door is more than about 200mm away from the receiver antenna.

Ultra-LD input impedance question

I would like to know the input impedance of the Ultra-LD Mk.1 amplifier module; not of the preamp associated with the stereo kit but just that of the power amplifier module itself as used in the Mk.1 stereo kit. I have searched all my documentation and on line but I haven't been able to find this out. (M. M., via email).

- The input impedance is complex and not easy to state in a single figure. If you want a rough idea, it would be 14.5kΩ which is the approximate impedance at 1kHz. Note that this is a different figure than would be suggested by simply looking at the input bias resistor which is 18kΩ.

Because it's an interesting question, we created a graph to show the impedance curve, ie, how the impedance changes over audio frequencies. This takes into account the reactance of the 2.2µF input coupling capacitor, RF filter (1kΩ/1.2nF) and the bias current of Q1.

As you might expect, the impedance is highest at very low frequencies, around 16kΩ at 10Hz, and drops markedly at higher frequencies, down to 6kΩ at 20kHz and 1.7kΩ at 100kHz.

This is because the RF filter, consisting of a 1kΩ resistor and 1.2nF capacitor, is effectively in parallel with the input bias resistor and since the 1.2nF capacitor's impedance drops with increasing frequency, this adds a parallel impedance to the 18kΩ resistor which approaches 1kΩ at very high frequencies. The input impedance will never drop below 1kΩ || 18kΩ = 947Ω and in fact will rise at very high frequencies due to parasitic inductance.

Then there's the 2.2µF coupling capacitor which is in series with the whole lot and so its impedance increases the overall input impedance but less so at higher frequencies, where its own impedance approaches zero.

Tempmaster to prevent pipe freezing

After building the Tempmaster Electronic Thermostat Mk.2, which is great for controlling from 2°C to about 20°C, I would like to modify it to control in the -20°C region to prevent an underground pipe from freezing during the winter. Here in Canada we get temperatures of -35°C to -40°C. Not knowing much about electronics, I do not know how to modify the unit to get to the 2.55V needed for the circuit. (G. L. Gore, Canada).

● If you replace the upper resistor in the voltage divider (2.7kΩ, between TP1 and pin 3 of REG1) with one having a value of 3.3kΩ, this will shift the voltage reference range down to 2.50V – 2.676V, giving a temperature range of -23°C minimum to -5.4°C maximum. We hope this suits your application.

Should you also need to bring the upper temperature limit above 0°C, this could be achieved by replacing VR1 with a trimpot having a maximum value of 1kΩ. This will bring the upper temperature limit to about +9°C.

Induction motor speed controller not required

I am thinking about building your Induction Motor Speed Controller for slowing a little a fan I have (a smaller version of the industrial-style pedestal fans currently available). The fan has a 3-position speed knob and appears to have a 2.5µF 450VAC capacitor wired in.

Do you think this motor would be a PSC (permanent split capacitor) type? Also do I just connect the controller to the first set of windings? I am currently using a Clipsal Universal Dimmer wired in series to the third position switch wiring, which is a bit variable as a speed controller. (E. P., via email).

● Unless the fan has a rating of say, 300W or more, it is likely to be a "shaded pole" motor. We really think that using the Induction Motor Speed Control for your application is overkill.

Capacitor discharge ignition is obsolete

I recently purchased a copy of SILICON CHIP's Electronic Projects for Cars, Vol 2. In it was a project for a High-Energy Capacitor Discharge Ignition system that I thought would fit my 2-stroke twin-cylinder motorbike.

I looked around for a kit but I only found the new CDI kit. Will this be suitable for my needs? If not, can you supply the PCB for the High-Energy CDI kit? (R. M., Casino, NSW).

● The Multi-Spark CDI from September 1997 (and as republished in Electronic Projects for Cars Vol.2) is now obsolete and the specialised parts are now difficult to obtain. The more recent CDI from May 2008 (Jaycar KC5466) is only suitable for your bike if the high voltage (at around 250-350VDC) is generated by the bike's electrical system. Usually a separate coil on the magneto is used to generate this voltage. The CDI unit then acts as a replacement for the original CDI module in the bike.

Courtesy light delay failure

I have had the Courtesy Light Delay project (SILICON CHIP, June 2004) circuit installed in my car for the last two years and it was working fine until recently. The courtesy light now stays half lit after the delay period and does not fully turn off.

Do you happen to know which part of the kit has failed in order to fix it rather than getting a new kit? (H. S., via email).

● It is possibly an open-circuit (or high resistance) 470Ω resistor (R1) that is allowing the 470µF capacitor (C1) to leak sufficient current to keep the Mosfet partially switched on. Either that or there is leakage on the PCB itself. Check to see if the 470µF capacitor and 47µF capacitor have leaked electrolyte. Alternatively, water may have caused corrosion and leakage on the PCB.

Power supply for a plasma speaker

I'm looking at making a plasma speaker and was wondering if your

Concerns About Excessive Mains Voltage

I seem to recall one Publisher's Letter in SILICON CHIP commenting on voltage and kWh costs. I think he may have been commenting on so-called Smart Meters in the same letter. I have looked through past copies of SILICON CHIP but can't find anything.

My reason for wanting this information is that I have had over-voltages issues at my place for some time now. My old house had the old black rubber insulated wire throughout and I had a real concern about the risk of fire. I pulled the old house down about 12 months back.

To me, the fire risk has now gone but my electronic equipment is still at risk of damage. The voltages that I'm seeing vary between 248VAC and up to 270VAC, every day. It's not good and I'm having all sorts of trouble getting SP Ausnet interested. I would be interested to see what these high voltages do to my kWh charges. (G. E., via email).

● The Publisher's Letter on Smart Meters was in December 2012 while the one on high voltages (from solar-powered grid-connect inverters) was in December 2011.

The higher voltages may not effect your overall electricity consumption by very much. Any radiators you are using in the winter would consume more, as would incandescent and halogen lamps. Your lamps are more likely to burn out prematurely though and some electronic equipment such as plasma TVs will definitely be at risk of failure.

Just coincidently, we have an alarm circuit in Circuit Notebook this month to indicate over and under voltage from the 230VAC mains but it would require an accurate digital multimeter in order to set it up precisely.

Questions Regarding DC-to-AC Inverters

I was wondering if I could I get a better AC waveform from a modified square wave converter (12V DC in 110VAC out) if I use a transformer on the output (120V to 120V). I don't have a scope so I cannot test the idea. I'm thinking the transformer may take the edges off the square wave or would it mimic the input exactly?

Secondly, I see that APCs are less expensive than DC-to-AC converters and it looks like you can buy those with higher wattage for less money. Could I just hook up my solar battery array to one and have (say) an 800W pure sinewave output for around $130 or would my battery array burn the converter up?

Also, my solar panels have an output of around 46.2V, My controller may handle it at 24V output but not at 12V output. What would happen if I used a zener diode to lower the voltage? Will it heat up my panels? (D. C., via email).

● The 120/120VAC transformer would not alter the modified converter output very much and the output would remain as a modified square wave. In other words, the output will not be rounded off to appear sinusoidal. The rise and fall times of the waveform may be slightly slower but that's all. The transformer would only add to power losses.

We assume that the APCs you refer to are the interruptible power supplies (UPS) used with computers. If these are cheaper than standard inverters, then they are probably only suited for short time use, with run time sufficient to shut down the computer but not continuous running. Generally, a UPS does not run at all until mains power is lost and then it switches on to maintain power for a short time only.

You cannot use a zener diode to control or reduce the voltage from a solar-panel array. You need a controller to suit the voltage output of the array.

Jacobs ladder designs were capable of operating at the required frequency with an automotive coil. I have a working 2007 Jacob's ladder otherwise I will start from scratch but would like to stick with the Commodore coil pack rather than a flyback transformer as most designs call for. (J. W., via email).

● The maximum spark frequency for a modern ignition coil is probably not much more than about 400 sparks/second which is equivalent to 8000 RPM for a 6-cylinder engine. As such, it is not suitable at all for a plasma loudspeaker which requires a continuous discharge which is modulated by the audio signal. None of our Jacob's Ladders have a continuous discharge; they are a very noisy spark.

Coil query on Barking Dog project

I have a query regarding the coil in the box with the tweeters, L1. Is it critical as mine only measured 155.3µH and you mentioned the resonant circuit as comprising a 200µH inductor and 220nF total capacitance across the four piezoelectric transducers. Where is the 220nF capacitor? It is not in the parts list or wired in the box. Can you clear this up? (R. S., via email).

● The coil inductance should be 200µH, so wind 20% more turns on the core. The 220nF mentioned is not a capacitor but is the capacitance of the four tweeters when connected in parallel. That is an inherent capacitance of the piezoelectric tweeters, ie, 55nF each.

Fast clock wanted for model railways

Your recent articles on various DCC items for model railway enthusiasts (10A DCC Supply and Reverse Loop Controller) were very welcome. One other essential item for model railway operation is a fast clock. The 12/24 hour clock from the March 2001 issue seems to fit the bill in size but the speed is not adjustable.

For model railways, usually the clock runs at either 3, 6, 9 or 12 times faster than real time to simulate railway time. The requirements for a fast clock are:

(1) Adjustable speed in steps.
(2) Able to be started at any particular time to suit schedules.
(3) Ability to pause the clock (when problems happen on the track).
(4) Ability to restart the clock from the paused position.

Could be clock from the March 2001 issue be modified to achieve these requirements or would a total redesign be required? Given the advancement in technology over the last 11 years, this design may be outdated. Would SILICON CHIP be interested in designing a new fast clock to suit? I am sure there would be uses other than model railways for such a clock, especially with the pause and restart function. (K. M., Bunya, Qld).

● The March 2001 clock would require extensive modifications to add

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WARNING!

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Ask SILICON CHIP

... continued from p94

a pause feature plus the rate change. Perhaps the Fast Clock published in December 1996 would be suitable. It is a small circuit that drives a standard sweep hand clock. The speed is adjustable from 4.5 to 8.5 times normal but changing the series resistor (820Ω to 220kΩ) that connects to the trimpot will allow a wider adjustment range. Additionally, changing the 150nF timing capacitor will alter the overall rate.

Adding a pause feature would be as simple as including a switch in the connection to the clock motor.

One disadvantage of the clock is that it is not 24 hour. However, the clock rate could be made slower so it takes 24 hours (model railway time) for the hour hand to rotate 360°. The clock face could then be remarked to show 24 hours rather than 12 hours.

Note that the PCB for this project is no longer available but the circuit is quite simple with only two ICs and you could easily build it on a piece of Veroboard.

Converting a 3-wire speed sensor

I own a 2001 VH Ford Transit van with a 2.3-litre petrol engine and a 5-speed manual gearbox. I have just converted the van to automatic, using a Jatco 4-speed overdrive box from a 1986 Nissan Pintara. This gearbox has a 3-wire VDO speed sensor whereas the Transit's manual box had a 2-wire speed sensor (like a single magnet with a toothed disc in box).

I know nothing about all this but from what I have read the 3-wire sensor is a "Digital Square Wave Pulse" and the 2-wire sensor is an AC sine-wave device. I went to my local Jaycar store but they couldn't help me with anything to convert the digital signal to a sinewave.

Do you know of any way of doing this with some sort of a kit? I would appreciate any help with this problem. (N. C, Caboolture, Qld).

● To convert the digital output of the 3-wire sensor to an AC signal, connect one lead of a 10µF NP (non-polarised) capacitor to the output of the sensor. The other lead from the capacitor will provide the AC signal and should be referenced by connecting a 10kΩ resistor between this AC signal and chassis. It's not necessary to convert to a sinusoidal wave shape since an AC square wave signal will be suitable.

Note that the VDO speed sensor will require power to its positive lead (+5V or +12V, depending on its requirements), while its GND lead must be connected to chassis. The output will be an open-collector transistor (which is located internal to the speed sensor). This will require a 1kΩ or similar value pull-up resistor from the output lead to the positive supply.

Temperature switch for fan control

I wish to switch on a series of small fans (65V @ 50mA) when the temperature on a heatsink reaches approximately 60°C. I do not require anything too precise or complex. Have you published any such circuits, possibly using the LM335Z? I see that Jaycar sells a Temperature Switch kit which may be based on one of your designs. (A. R., via email).

● The Temperature Switch is a SILICON CHIP design sold as a kit by Jaycar and this can be used. Or just use a 60°C thermostat (Jaycar Cat. ST-3821) that opens its contacts at 60°C and re-closes at 40°C. Other temperature switch point thermostats are also available from Jaycar. SC

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K318 10W WEATHER-PROOF FLOODLIGHT KIT

This kit comes complete with 1 X 10W LED, 1 X 10W LED driver kit, 1 X Weatherproof, diecast aluminium housing

ONLY $27

As reviewed in Silicon Chip Magazine.

10W LED FLOOD LIGHT KIT PACKAGE

2 lamps wired in series with our 24V PSU.
2 X LED FLOODLIGHT KITS + 1 X 24V POWER SUPPLY [K318P] $50

FLEXIBLE 12VDC LED STRIP WATERPROOF (IP65)

3W per 500mm

These LED strips are designed to operate from nominal 12VDC regardless of length Ideal for use in cars, boats. caravans and sheds etc. With a self adhesive backing and a clear PVC front coating. These strips can be easily joined or connected by wire to form greater lengths or can be cut into multiples of 100mm. [LS500R] $40 PER 5M roll or [LS500] $6 per 500mm

BARGAIN LOW VOLTAGE LIGHTING PACKAGE

This package contains 5 12V-24V, 4Watt LED "PURE WHITE" MR16 replacement lamps + a 240VAC - 24V / 1A switch mode power supply that can power all 5 lamps.

$40

[K329P]

20W FLOODLIGHT KIT

20W Pure White Floodlight kit with an output of 1800-2000 Lumens!

Includes: 24V- 1A Power adapter that can power this Floodlight from 100-240VAC.

Supplied with a pre-assembled Switched mode Driver PCB: Quick and simple to complete. 6-30V DC, 180 X 140 X 110mm 0.95KG's.

DUAL BEAM INFRA-RED FENCE

It comes brand new in original packaging with mounting brackets. Features include.. weather-proof housings, separate transmitter & receiver units. Up to a 100M range, normally open and closed contacts, fine vertical & horizontal adjustments,analogue output for easy setup, tamper switch.12V-22V DC / 10-16VAC dim W69 X H212 X D76

[IRF] $49

3 Lamp pack 6W/10W LED DOWN-LIGHT KIT

This kit is easy to construct and includes all the mechanical parts, 3X3W LED's and a pre-assembled Switched Mode driver PCB. There is sufficient heatsinking for 6W operation, but additional air circulation (Small fan) would be required for 10W operation. This kit contains all the parts to build 3 6W/10W lamps

[K327P] $27.00

PRE-BUILT CODE HOPPING 4 CHANNEL REMOTE CONTROL

This kit is pre-built (requires soldering of 2 wires). Has individual limit/reset input for each channel. Combined with our TX8 Transmitter (not incl.), this kit can control any combination of four output relays in either momentary or latching operation. Features inc. range of ~50m, indicator LEDs, & screw terminals for ease of use.

[K338] $15.00

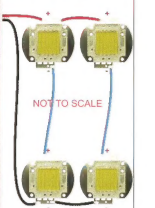
3W LED LAMP AND PIR KIT

This package includes 2 x 3W LED lamp kits plus 1 X 360deg PIR movement detector and a suitable 240V mains adaptor.

[K318PIR] ONLY $25

SPECIALS

SOLAR SKYLIGHT KIT [K328] Special introductory price $109.00 1200 X 600 PANEL



Don't let the price fool you, these is a high quality solar panels and LEDs. Inc. one "First Solar" brand FS-272 72W/66V/12KG Panel + 4 20W-34V-0.7A LED's. The LEDs are connected in series/parallel & will require some heatsinking, they give a total of OVER 5000 LUMENS! This system is self regulating, simply connect the panel to the LEDs. The Cadmium Telluride (CdTe) cells are sandwiched between 2 sheets of glass with rounded, polished edges, they are totally sealed and waterproof & have better performance at higher temperatures & in lower light.

72W SOLAR PANEL WITH A 12/24V REGULATOR CHARGER KIT

The above 72W Solar Panel is also available with a 12V Regulator/Charger kit. The overall efficiency in transferring power from the panel to the batteries is around 90%: The kit includes a 72W Solar panel plus the Charger kit. If the postage cost is of concern send your address and contact details and / or an order by email to: branko@oatleyelectronics.com
Available mid September. [K330P] $119.

SKYLIGHT DIMMER KIT

This kit is designed to be used with our Solar Skylight Kit, it's dimming ratio is 10:1 This kit comes with the PCB and all onboard components, pot and knob. **[K334] $10**

20W LED + DRIVER SPECIAL

This kit comes with a 20W, 2000lm "PURE WHITE" LED plus a 12Vdriver kit plus a small fan. The LED will need to be mounted on a small plate or heatsink.

Post & Pack typically $7 Prices subject to change without notice ACN 068 740 081 ABN18068 740 081

Introducing Microchip's New 16-bit dsPIC33E Digital Signal Controllers and PIC24E Microcontrollers

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